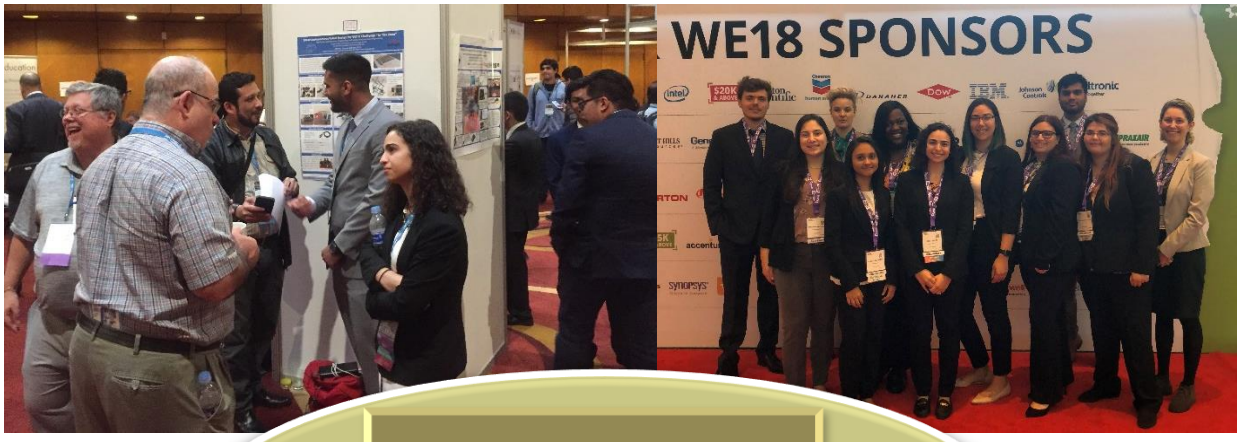
Vaughn College Journal of Engineering and Technology
April 2019



EMPOWER

"Tell me and I forget. Teach me and I remember. Involve me and I learn."
Benjamin Franklin

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 outlook through which they recognize the benefits of lifelong learning to meet future professional challenges. The Journal's ultimate aim is to engage and prepare students for their future in engineering research and innovation. This journal further strengthens student learning outcomes related to critical thinking, problem solving, communication, and teamwork. These learning outcomes, derived through engineering and engineering technology programs, are further enhanced through the activities outlined in this publication. These events, reported in this journal, also contribute to student development of leadership and entrepreneurial skills.

A journal paper project must be developed and investigated in such a manner that it 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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Contents

A Brief Review of Vaughn College's Tenth Annual Technology Day Conference, April 20, 2018

Vaughn students, faculty, alumni, and industry professionals convened in April 2018 for the College's Tenth 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: the new Mechanical and Electrical Engineering programs, programs' assessment and preparation for the ABET 2019 programs reaccreditation, HSI-STEM grant activities including development process of stackable manufacturing certificate programs that lead to a BS in advanced manufacturing program, development process of manufacturing laboratories (CNC machining, composite, additive manufacturing, and UAS), qualification of two Vaughn's Robotics teams for 2018 VEX U world championship, the selection of Vaughn's UAV team by the American Helicopter Society (AHS) as a finalist alongside Penn State, University of Maryland to participate in the 6th annual Micro Air Vehicle (MAV) student challenge competition in Phoenix Convention Center (May 14, 2018), and engineering clubs' (SWE, EWB, NSBE, Robotics, SAE, SHPE, UAV) annual stem outreach activities.

Vaughn College's Academic Vice President, Dr. Paul LaVergne, welcomed the guests and thanked our advisory members for their active participation and input toward programs' enhancement. Dr. Hossein Rahemi, Chair of Engineering and Technology Department, thanked the advisory members for their continuous support and valuable feedback in every aspect of the department's programs and students' 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 measuring and attaining student learning outcomes within various engineering and engineering technology programs. Dr. Rahemi discussed students' scholarly and professional activities including the success of the Vaughn College Robotics team as the 2017 Mexican International VEX U Robotics Champion as well as their qualification to participate in the 2018 VEX U World Championship, participation of Vaughn's UAV team as finalists in both manual and autonomous categories by The American Helicopter Society (AHS) for the Annual Micro Air Vehicle (MAV) Student Challenge competition on May 14, 2018 in Phoenix, student participation and presentations in paper and poster sessions of technical conferences, updates on student and faculty professional development and engineering club STEM outreach activities. Also, he informed advisory members about the Department of Education title III HSI-STEM grant funded activities including the development process of manufacturing laboratories, stackable certificate programs in Computer Aided Design & Additive Manufacturing, Composite Manufacturing, CNC machining, PLC & Automation, and a new BS in the Advanced Manufacturing program.

The third speaker of the morning session conference was Prof. Jesus who introduced the audience to courses for both CNC machining and additive manufacturing certificate programs. Also, he introduced the advisory members to a list of laboratory equipment related to software, hardware, 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 preparation and design process for two manual and autonomous quadcopters for participation in the 2018 American Helicopter Society Micro Air Vehicle Competition. Vaughn's UAV team 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 in Phoenix Convention Center on May 14, 2018. 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 would then takeoff from the delivery station and land on the pickup station to pick up a 2nd 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 2017 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. Among all participating teams, only teams from the University of Maryland and Vaughn College were able to complete the remotely-operated tasks within the 10 minute time limit to win the 2017 Micro Air Vehicle competition.

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) were tournament champs of Vaughn College Regional Robotics Competition; the second Vaughn robotics team (VCAT2) was a tournament finalist in the West Virginia regional competition as well as the tournament champion of 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. The objective is to stack cones on mobile goals and place them in far, mid, and near zones as fast as possible. Both teams also talked about their defensive and offensive strategies for both autonomous and driver controlled periods. From April 25-28, Vaughn's Robotics teams will be competing with eighty-seven national and international universities and colleges for the 2018 VEX U Robotics World Championship in Louisville, Kentucky Freedom Expo Center.

Vaughn's Robotics Club Presentation

- The Engineers Without Borders (EWB), the Vaughn Society of Women Engineers (SWE) and the new formed Society of Automotive Engineers (SAE) made presentations regarding their annual activities, extra-curricular involvement, and STEM outreach activities.

Vaughn's EWB, SWE, and SAE Clubs Presentation

<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 2018 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 winner, 1) **Autonomous Package Delivery Drone** by Utsav Shah and Lovedeep Kaur, 2) **FSAE Chassis Design** by Parth Bhatt and Alana Hasselman; second place research paper winner, "**Concepts of Mechatronics in Maritime Life Aquariums**" by Emily German, Luis Goncalves, Alaric Hyland; and two third place research papers winner, 1) **Team Cleaning Robots** by Daniel Khodos, David Adegbesan, Oliver Khairallah, 2) **Mechanical Design of an Exoskeleton** by Moustafa Youssef.

Students' Capstone Paper Presentation

<u>Students' Capstone and NSF posters Presentation, 2:30 pm – 3:00 pm</u>

The top 2 posters (NSF's project poster and capstone degree project poster) 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 was "**Pilot Health Monitoring System**" by Renaldo Francis; the second place poster winner was **"Mechatronics in the Advancement of**

Automated Climate Control" by Maia Rivers, Jamal Sharifi, Denis Nekrasov. The first place NSF Learning Community poster winner is, "**Expanding the Network of Cosmic Ray Detectors to Vaughn College**" by Samantha Maddaloni, the second place poster winner is, "**Automatic Assisted Walking Cane"** by Richi Ramlal & Muhammad Galib.

Students' Capstone Degree Projects and NSF and Posters Session

Tenth Annual Advisory Meeting and Technology Day Conference, April 20, 2018

The Engineering and Technology Department expresses sincere gratitude to Oliver Scheel for his continuous support and contributions.

For the past several years, Mr. Scheel, a Director of US Didactic, has served as an active advisory member of the Department of Engineering and Technology. He provided assistance and recommendations to the engineering department regarding laboratory development, program enhancement, and necessary support to engage students in professional and scholarly activities. In 2012, with his assistance the department established two new state-of-the-art thermos-fluid and mechatronics laboratories, and in 2015 and 2016 he assisted us with the establishment of a new Energy Conversion and smart grid power electronics laboratory. This lab will provide students with practical hands-on skills and will complement lecture courses in power electronics in our new electrical engineering program.

An industry leader, Mr. Scheel has been a guest speaker at the Vaughn Industry Connection Seminar series as well as at the annual manufacturing day conference and at the Summer Engineering Experience – STEM workshop session. He delivered and addressed Vaughn's students and community about topics related to Advanced Manufacturing into Cyber Physical Systems, Sustainable Energy and Manufacturing Fundamentals, and Robotics and automation.

For past several years, his considerable contributions to student engagement helped the engineering and technology department to advance student involvement in Robotics, UAV, EWB, and Automotive club activities, technical competitions (Robotics and UAV) as well as scholarly activities (conference papers and presentations).

The entire Vaughn community offers kudos and gratitude to Oliver Scheel, and we look forward to working with him for many years into the future.

Mr. Scheel's contributions greatly assisted Vaughn engineering students' involvement in the following activities during the 2018-2019 academic year:

1. Participation in regional, national, and international VEX U Robotics Competitions.
    - From April 25-28, 84 national and international universities and colleges received invitation to participate in the 2017 VEX U World Championship in Louisville, Kentucky, Freedom Expo

Center. Vaughn's robotics team received ranking in the top eight out of 84 participating teams in the *innovate* division of the 2018 world championship. Vaughn's team retained their standing as one of the top competitors (top eight teams) in the world championship by advancing, for five years in a row, to the quarter-final of the playoff round in this intense competition.

- From November 21-23, Vaughn College Robotics participated and competed in the Signature International Mexican VEX U Challenge competition in the Univeredad Politecnica De Quintana Roo, Cancun, Mexico. The team finished second place overall in the competition and earned first place in the robotics skills (Programming and driving skills) champion category and is currently first in the world in the skills category. For the past four years, Vaughn's robotics team members consistently demonstrated persistence and drive in order to attain their title as champions and top competitors in Mexico's VEX U Robotics competitions.
- In June, 2018, Vaughn's students' research paper "**'Team Cleaning Robots**," **by** Daniel Khodos**,** David Adegbesan**,** Olliver Khairallah was presented during the **Capstone Project Session** (Monday June 25, 1:30pm-3:30 pm) at the 2018 ASEE annual conference, Salt Lake City, Utah.
- From July 17-20, Vaughn students participated in the student paper and poster competition of LACCEI 2018 conference in Lima, Peru. One of Vaughn's student team papers **"Smart Autonomous Robot Design for VEX U Challenge - In the Zone"** by Niki Taheri, Atif Saeed was selected to compete among ten finalists for the student paper session of the LACCEI 2018 conference. Their paper received the third place award for the best paper presentation of this session
- In November, 2018, Vaughn engineering students participated in the 2018 Society of Hispanic Professional Engineers (SHPE) National Conference in Cleveland, Ohio. The Vaughn team participated in the Extreme Engineering Challenge (a non-stop, 24-hours competition) and Vaughn's student, **Angel Calderon's** group, whose design topic was "**Adaptive Air Intake** – Enhancing efficiency of existing engines and reducing carbon footprint" won first place in the Nissan Challenge competition for a $10,000 check award.
- In October, 2018, Vaughn's SWE club participated in the 2018 SWE Annual Conference in Minneapolis, Minnesota. At the event, the Vaughn team hosted a STEM mini-piano workshop which taught students the basics of circuitry. The Vaughn students also participated in the SWE career fair event, and many of them received both internships and employment offers.
- 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 the Phoenix Convention Center on May 14, 2018. The Vaughn UAV team finished first in this challenging competition in both remote control and autonomous categories and was awarded a check for $3000.

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 (his) 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, and AC/DC circuits, 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 ($70,000/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 fall 2018 the student supplemental instructors and their schedule are presented in the following table.

Fall 2018 SIs for the Corresponding Courses and Course Schedule

Course	Faculty	Supplemental Instructor	Class Schedule	Out-of-Class TLC Schedule
EGR220 Strength of Materials	Rahemi, Hossein	Abdalmonem Anwar	MO 10:00am-11:30am	M:9:00-10:00pm; 12:00-2:00pm W:9:00-10:00pm; 12:00-2:00pm; 4:00-6:00pm TH:3:30-6:00pm F:9:00-2:00pm
EGR260 Aerodynamics I	Elzawawy, Amir	Abdalmonem Anwar	WE 10:00am-11:30am	M:9:00-10:00pm; 12:00-2:00pm W:9:00-10:00pm; 12:00-2:00pm; 4:00-6:00pm TH:3:30-6:00pm F:9:00-2:00pm
EGR235:Material Science and Composites MEE235:Material Science	Budhoo, Yougashwar	Nicolas Ceballos	MO 9:00am-10:30am WE 9:00am-10:30am	M:9:00-1:00pm T:11:00-12:00pm W:9:00-1:00pm

& Failure Analysis				
EGR460 **Engineering Economics**	Mukund Joshi	Shady Mohammed	WED 6:00pm-8:50pm	T:10:00-12:00pm TH:11:00-3:00pm
EGR489 **Patran Nastran Structural Analysis**	Sypeck, Jonathan	Aderet Pantierer	TU 6:00pm-6:50pm	M:9:00-12:00pm; 4:00-6:00pm T:4:00-6:00pm
ELE117 **DC/AC Circuits**	Ramabhotla Sundari	Laube, Dylan	MO 12:00pm-1:30pm WE 12:00pm-2:30pm	
ELE326 **Microprocessors**	He, Shouling	Hector Sabillon	TU 1:00pm-2:50pm TH 12:00pm-2:50pm	M:1:00-5:00pm T:1:00-2:00pm; 5:00-7:00pm Th: 10:00- 12:00pm F:12:00-5:00pm
MCE101-ELC **Introduction to Robotics**	Tang, Ryan	Janson Becker	MO 2:00pm-5:00pm	Assisting students during lab hours
MCE101 **Introduction to Robotics**	Tang, Ryan	Khedaru Nizamadeen	WE 3:00pm-6:00pm	Assisting students during lab hours
MCE310 **Fundamentals of Mechatronic Engineering**	He, Shouling	Eric Grieco	MO 12:00pm-1:50pm WE 12:00pm-1:50pm	F:10:00-4:00pm
MCE410 **Mechatronics I**	He, Shouling	Hector Sabillon	MO 10:00am-10:50am WE 9:00am-11:50am	M:1:00-5:00pm T:1:00-2:00pm; 5:00-7:00pm Th: 10:00- 12:00pm F:12:00-5:00pm
MEE115 **Statics**	Jahnke, Douglas	Samantha Vitez	MO 12:00pm-1:50pm WE 12:00pm-1:50pm	M:9:00-12:00pm W:9:00-12:00pm
MEE220 **Strength of Materials**	Budhoo, Yougashwar	Nicolas Ceballos	MO 12:00pm-1:50pm WE 12:00pm-1:50pm	M:9:00-1:00pm T:11:00-12:00pm W:9:00-1:00pm
EGR455: Aircraft Structural Analysis **EGR350: Mechanical Vibration**	Budhoo, Yougashwar	Nicolas Ceballos	MO 10:00am-11:30am WE 10:00am-11:30am	M:9:00-1:00pm T:11:00-12:00pm W:9:00-1:00pm
MEE340 Computational Methods w. MATLAB	Rahemi, Hossein	Shmuel Pantierer	TH 6:00pm-8:50pm	M:8:30-12:00pm W:8:30-12:00pm TH:4:00-5:30pm
MEE370 **Finite Element Analysis**	Rahemi, Hossein	Aderet Pantierer	TU 5:00pm-5:50pm TH 4:00pm-5:50pm	M:9:00-12:00pm; 4:00-6:00pm T:4:00-6:00pm
MEE340 **Computational Methods with Matlab**	Rahemi, Hossein	Mary Chinskul	MO 4:30pm-6:00pm WE 4:30pm-6:00pm	T:6:00-9:30pm W:6:00-9:30pm
CDE117 **Computer Aided Design I (CAD I)**	Mouaouya, Khalid	Adham Mostafa	TH 8:00am-11:00am	M:9:00-1:00pm W:9:00-1:00pm

2018 Department's Activities and Highlights

1. **STEM related student engagement (Technical Competitions and Conferences):**
   - Vaughn's students Hector Sabillon, Darwing Mota and David Adegbesan were chosen from a pool of 350 candidates from engineering schools across the United States to participate in the Extreme Engineering Challenge competition as part of the **Society of Hispanic Professional Engineers (SHPE) National Conference**. Student, Darwing Mota's group, whose design topic was related to an **active suspension system,** received the third place award of the Nissan challenge competition along with a $2500 check.
   - On January 27, 2018 Vaughn College hosted a regional VEX U Robotics competition with thirteen college teams participating at this event, Vaughn's robotics team finished first place, winning the tournament championship along with the first place skills' awards. The team also qualified to participate in the 2018 VEX U World Robotics Championship.
   - On Friday March 2, 2018, Vaughn College's Robotics team participated at the Fairmount State University (West Virginia) VEX U Robotics Regional Tournament. A total of nineteen colleges and universities participated in the event. VCAT2 won both "Finalist" and "Robot Skills" championship awards. With this win Vaughn College had two teams (VCAT and VCAT2) qualified to participate in the 2018 VEX U world championship in Louisville, Kentucky, April 25-28, 2018.
   - From April 25-28, the Project Director and twelve members of Vaughn's Robotics club traveled to Louisville, Kentucky to participate in the 2018 VEX U Robotics competition. Eighty Seven (87) national and international universities and colleges were invited to the 2018 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 in which 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, winning seven out of the 10 matches and advancing to the Saturday afternoon playoff round. The top 16 teams competed during single elimination of the playoff round, with Vaughn's team defeating a top ranking team from Mexico (number one in the "innovate" division) and advancing to the quarter-final. Even though there were issues with the judging process during the quarterfinal match, our team retained their standing, for the fifth year in a row, as one of the top competitors (top eight teams) in the 2018 world championship by advancing to the quarter-final of playoff round of this intense competition.
   - Vaughn's UAV team participated as a finalist beside Penn State University and the University of Maryland for both autonomous and manual categories in the 2018 American Helicopter Society (AHS) Micro Air Vehicle student challenge competition at Phoenix Convention Center, May 14, 2018. Among all participating teams, only Vaughn College and the University of Maryland were able to complete the remotely-operated tasks within the ten-minute time limit. Vaughn's remote control team was the only team that completed three flawless successful runs within the 10 minute time allowance. For the autonomous session, only Vaughn's autonomous team was able to fly its drone with vertical takeoff and partial hovering around the field. On Tuesday

May 15, Judges from aerospace industries evaluated the teams' performance in both the remote and autonomous control categories. Vaughn's UAV team received the highest score in both categories. As the 2018 winners of the Micro Air Vehicle competition, Vaughn's remote control team received the "Best Remotely-Controlled Target Search" award (**First place award**) with a **$2000 check**. Vaughn's autonomous team is the only team who, for the past three years, was able to attain vertical take-off and partially complete the autonomous category, and for this achievement they received "Honorable Mention" along with a **$1000 check**.

- Vaughn's students' research paper "**"Team Cleaning Robots," by** Daniel Khodos**,** David Adegbesan**,** Olliver Khairallah was presented during the **Capstone Project Session** (Monday June 25, 1:30pm-3:30 pm) at the 2018 ASEE annual conference in Salt Lake City, Utah.
- From July 17-20, the following Vaughn student research papers were selected to compete among ten finalists for the student paper session of the LACCEI 2018 conference in Lima, Peru.
    - "**Smart Autonomous Robot Design for VEX U Challenge - In The Zone"** by Niki Taheri, Atif Saeed
    - "**Development Process of a Smart UAV for Autonomous Target Detection"** by Utsav Shah, Ryan Tang Dan
    - Three of Vaughn's student team posters were selected to compete for the student poster session of the LACCEI 2018 conference, and among 45 participating teams, Vaughn's **Smart Autonomous Robot Design for VEX U Challenge - In the Zone** poster by Niki Taheri and Atif Saeed received third place award for the best poster presentation of this session.
- **2018 Society of Hispanic Professional Engineers (SHPE) National Conference:** From Nov 7-10, a group of 17 engineering students from Vaughn College attended the 2018 Society of Hispanic Professional Engineers (SHPE) Conference in Cleveland, Ohio. Vaughn's students participated in the design competition as well as in various professional development workshops aimed at promoting leadership, unity, and exposure to the diverse career opportunities in the STEM fields. Vaughn's Engineering student, **Angel Calderon**, participated in the Nissan Design Challenge and won **first place** in this Extreme Engineering competition for his innovative design idea "Adaptive Air Intake – Enhancing efficiency of existing engines and reducing carbon footprint."
- **2018 Mexico's VEX U Signature Reeduca Robotics Competition:** From November 21-23, Vaughn College Robotics participated and competed in this Signature VEX U Challenge competition in the Univeredad Politecnica De Quintana Roo, Cancun, Mexico. Seven members of VCAT robotic club (Niki Taheri, Jason Becker, Juan Rodriguez, Atif Saeed, John Hernandez, Eric Grieco, and Andriy Belz) and two advisors, Dr. Hossein Rahemi and Prof. Khalid Mouaouya, represented Vaughn College at this competition. **The team finished first place for the robotics skills (Programming and driving skills) champion category and second place overall in the competition**. For the past four years, Vaughn's robotics team members consistently demonstrated persistence and drive in order to attain their title as champions and top competitor in Mexico's VEX U Robotics competitions.

2. **Lab Equipment, Laboratory Enhancement and Development:**

- On July, Prof. Manny Jesus, CNC/3D curriculum designer, completed purchase and installation of Stepcraft CNC-3D printer and laser cutter machine**.** This machine will be used to conduct multi-purpose tasks from manufacturing a part (using both CNC and 3D printing additive manufacturing) and cutting any part (metal, wood, carbon fiber, and plastic) up to 3/ length. It can be used by students in technical clubs (robotics, UAV, SAE) and capstone degree projects for developing and manufacturing parts and components for their specific project.
- Dr. Y. Budhoo, Composite/Manufacturing curriculum developer, completed purchase of Instron Tensile testing machine. In fall 2018, Instron completed installation of this machine in mechanical testing lab and provided a day training to our faculty. The tensile machine can be used to determine mechanical property related to material's elastic modulus, yield strength, ductility, fracture strength, and fracture toughness.
- Dr. Shouling He using her background in control and automation is assisting the department with the development process of PLC and Automation certificate and lab equipment. The Project Director currently completed a purchase request for automation sub-system lab equipment through U.S. Didactic Inc and we expect installation and training to be completed during spring 2019.
- In March 2019, the department placed the purchase order for equipment listed below to facilitate CNC machining and manufacturing laboratory development as well as the certificate program in CNC.
    - ✓ Okuma Genos L200E Lathe machine
    - ✓ 3D coordinate measuring machine (CMM)

  This laboratory will provide students in the advanced manufacturing program and other STEM related fields with practical hands-on training in CNC programing and Machining.
- **CNC Lab Tech Specialist:** At the end of October, Mr. Igor Brekman, due to personal reasons, resigned his lab tech position and the department placed an ad for a new CNC lab Tech specialist. The search committee, after collecting and conducting phone and campus interviews, selected Mr. Rachid Nafa for the manufacturing Laboratory Technician position. He has an extensive background in CNC Machining and Mr. Nafa accepted the position and started at Vaughn on Dec 17, 2018.

3. **Faculty Training, Conference Participation and Professional Development:**
    - **Composite Manufacturing Training:** On May 14, 2018 Dr. Budhoo, composite prototype curriculum designer, attended a five days training on advanced composite manufacturing II in Reno, Nevada. The purpose of this training was to enhance his knowledge and skills in composite manufacturing so he can teach our students in the composite certificate program with technology that is current in today's manufacturing industries.
    - **Design and Manufacturing Conference:** From June 11-15, 2018 Professor Manuel Jesus, 3D/CNC curriculum Designer, attended the Atlantic Design and Manufacturing Conference held in NYC at the Javits Center in Manhattan. The show was a great opportunity to engage with companies that develop a variety of manufacturing equipment. Prof. Jesus attended the show to explore new developments in 3D metal printing and he discovered significant advancements.

- **Electrical Machine, Power Electronics, and Power Systems Training:** The Department organized a three day (Nov 11-13) power electronics & systems training with U.S. Didactic and Lucas-Nulle. This training provided three of Vaughn's engineering faculty members and a lab tech with the hands-on laboratory skills regarding electrical machines, power electronics, motor drives circuits & controllers, as well as contemporary techniques in power generation, power transmission, power distribution, and energy management of load consumption.
- **UAS Training:** On Tuesday Dec 11, Aeronautical Curriculum Designer, Dr. Elzawawy conducted a site visit to 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 providing our engineering students with the ever-advancing technical skills required in this developing field.
- **Conference Presentation:** The Department chair along with two other faculty members participated at the 2018 ASEE annual conference and presented their paper titled "**Enhancing student learning outcomes through the freshmen Summer Engineering Experience (SEE-STEM) Program",** during **Student Success session** (Monday June 25, 1:30pm-3:30 pm) of this annual gathering.
- **Conference Presentation:** Dr. Rahemi along with Dr. Elzawawy (Aero curriculum developer) participated at the 2018 ASEE annual conference and presented their NSF S-STEM project titled "**Increasing Student Enrollment and Achievement in Engineering and Engineering Technology**." during the NSF Grantees Poster Session (Monday June 25, 9:45 am-11:15 am).
- **Conference Presentation:** On Wednesday (8:00 am – 9:30 am), June 27, Vaughn's faculty, Dr. Shouling He presented her paper titled "**Multi-sensors for Robot Teaching Using Raspberry PI and VEX Robotics Construction Kits.**" during the Automation in Manufacturing session of 2018 ASEE Annual Conference.

4. **STEM related Workshops by Students and Faculty:**
   - **Maker Workshop by Vaughn's SWE Students:** From September 22-23, a total of 25 students from Vaughn's STEM programs, UAV, SWE, EWB, NSBE, Robotics, and SHPE clubs participated in World Maker Fair event in Queens, NY. The Vaughn Society of Women Engineers chapter hosted a STEM workshop (how a motor works) at this World Maker Faire. The project they hosted was a small circuit with a 3D printed base that created a car as the end product. This project allowed for students to learn the basics of how a circuit works, as well as how a motor works.
   - **Advanced Manufacturing Workshop (CNC) - HAAS Basics for Faculty and Students:** On September 17, Igor Brekman, Manufacturing Lab tech, demonstrated the HASS CNC lab to students and faculty. Topics included setting tool and work offsets, working the MCU panel, and work holding. The importance of safety and machining strategy was discussed. After the introduction, students were shown how a program is loaded into the MCU and prepared for milling. Normally a metal stock material such as aluminum would be used; however, a 3D printed ABS stock plastic block was used for demonstration purposes. Due to the interest in this demo, more workshops are scheduled in the future.
   - **Advanced Manufacturing Workshop (CNC)**-

- **HASS AND MASTERCAM:** On October 2, Igor Brekman demonstrated how to run the HAAS VF2 SS CNC machine. This demonstration centered on the process of preparing files to milling using MasterCam. CAM programs were discussed in general. G-Code edits were discussed in brief, however the importance of using CAM programming software for 3D parts instead of impractical G-Code programs was explored in detail. Brekman was able to POST the CAM file to a USB drive and initialize the program on the HASS.
- **HOBBYSIT / CLUB ACTIVITY STEPCRAFT CNC:** On Friday October 5th, students in the UAV club were treated to a demonstration of the StepCraft 840 Desktop CNC machine. This device differs greatly from the industrial HAAS range of CNC machines as its design intent is focused around quick and easy implementation of CNC tasks. The work area is ideal for UAV projects and as many of the parts required consist of 2D milling on composite plates. The simpler operation and low-cost easily replaceable parts make this machine a beneficial complement to the HAAS.

❖ On Friday June 14, Prof. Manuel Jesus, Vaughn's 3D/CNC curriculum designer, attended **Atlantic Design and Manufacturing** show in Manhattan. The show was a great opportunity to engage with companies that develop all sorts of manufacturing equipment. Prof. Jesus attended the show to explore new developments in 3D metal printing. The event exhibited a range of manufacturers including industrial electronics and machine shops.

5. **Hosting STEM related Conferences and Seminars:**

❖ **4th Annual Manufacturing Day Conference:** The Department hosted the 4th annual manufacturing day conference on Friday October 19 (10 am to 2 pm) to celebrate National Manufacturing Day. The guest speakers addressed Vaughn community, faculty, and invited guests about current manufacturing innovation in the area of aerospace, additive manufacturing, composites, CNC machining and manufacturing. In a parallel session, from 10 am to 2:00 pm, Vaughn's Robotics and UAV clubs organized and hosted STEM workshops for high school students. More than sixty students from Queens and Long Island high schools (Freeport public high school, Bay Side high school, Thomas Edison High school, ESBOCES Engineering, and West Islip high school) participated in a STEM workshop session at this national event.

❖ **10th Annual Technology Day Conference:** On Friday April 20, 2018, the Engineering and Technology department hosted its Tenth 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: the new Mechanical and Electrical Engineering programs, program assessment and preparation for ABET 2019 reaccreditation, HSI-STEM grant activities including the development process of stackable manufacturing certificate programs that lead to a BS in the advanced manufacturing program, development process of manufacturing laboratories (CNC machining, composite, additive manufacturing, and UAS), qualification of two Vaughn's Robotics teams for 2018 VEX U world championship, and the selection of Vaughn's UAV team by the American Helicopter Society (AHS) as a finalist alongside Penn State, University of Maryland to participate in the 6th annual

Micro Air Vehicle (MAV) student challenge competition in Phoenix Convention Center (May 14, 2018).

- ❖ **Annual International Drone Day:** On Saturday May 5, 2018, 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 Zion's program, Robert F. Kennedy Community, Thomas Edison, and Bayside high schools.
- ❖ **Industry Connection Seminar Series:**
  - Department arranged and hosted the first fall industry connection seminar series on Thursday September 20. The industry guest speaker, Ms. Leonie Barden, a 2007 Vaughn College graduate and a systems engineer for the Boeing Company at the Kennedy Space Center, addressed the Vaughn community on Thursday, September 20 as part of the College's Industry Connection Seminar series.
  - Department arranged and hosted the 2nd fall Industry Connection Seminar series on Friday, November 2. The industry guest speaker, Mr. Asaro, a senior avionics engineer at Sikorsky Aircraft Corporation, addressed the Vaughn community as part of the College's Industry Connection Seminar series. His presentation focused on the qualifications required for avionics systems designing in the aerospace industry.
  - Department arranged the final fall Industry Connection Seminar series on Tuesday, December 4. The industry guest speaker, Mr. Matthew Pearce, NASA Education Programs Specialist. Mr. Pearce presentation provided an Overview of the NASA, STEM Workforce Challenges, and NASA's Internship, fellowship programs and how to apply for those career-building opportunities with NASA.

6. **STEM Outreach Activities:**
   - **Long Island STEM HUB Career Conversations:** On Wednesday October 24, 2018, the Project Director, faculty, students, and staff from Vaughn College attended the Long Island STEM HUB careers Conversations at the Cradle of Aviation Museum in Garden City. The event was well attended with enthusiastic participants. Many industries and colleges from Long Island and NY City gathered to inform middle and high school students about STEM educational and career opportunities. Vaughn's engineering and technology department chair, Dr. Hossein Rahemi, along with faculty members Dr. Amir Elzawawy, Prof. Manuel Jesus, and students from robotics and UAV interacted with students and provided them with insight into Vaughn's STEM programs and professional career opportunities.
   - **Borough of Manhattan Community College STEM Workshop**: On Wednesday October 24, 2018, Prof. Mudassar Minhas attended a STEM workshop at BMCC to make a presentation regarding Vaughn's engineering and engineering technology programs and Vaughn student involvement in technical clubs and scholarly activities. Furthermore, as part of the active program articulation with Community Colleges (BMCC, Bronx Community College, QCC, Bergen, and others), the Project Director with the help of the STEM pathway Liaison is planning to arrange

and host an annual interactive STEM workshop at which students from these colleges will be invited for a day of hands-on drone and robotics activities.

- **Hosting K-12 STEM Workshop at 2018 SWE Annual Conference:** From October 17-20, Vaughn College's chapter of the Society of Women Engineers attended, presented, and held a STEM workshop at the WE18 Conference in Minneapolis, Minnesota. The 12 VCAT-SWE attendees were extremely successful. As a whole, Vaughn's students received 34 interviews with companies such as Northrop Grumman, Boeing, Lockheed Martin, Daimler Trucks North America, Cummins, Medtronic, NASA JPL and Raytheon. Of those 34 interviews, 6 internship offers were made and as well as 5 full-time job offers. On Saturday October 20th, 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 mini piano workshop that allowed students to learn the basics of circuitry while asking questions about Vaughn College.

7. **Other Department's STEM related Activities:**
   - **Budget Changes:** On July 17, the Department chair submitted budget changes to the project officer for the first year carryover balance, due to a project staffing and renovation delay. The Department chair provided an updated budget and supporting documents to address the use of the carryover balance toward additional laboratory equipment and renovation costs for expansion of the CNC and composite labs.
   - In July 2018, the Department chair met with Vaughn's Teaching and Learning Center (TLC) coordinator, Mr. Frank Wang, and discussed the selection criteria for Supplemental Instructors and Mentors for the fall semester. Mr. Frank Wang will coordinate with program coordinators and faculty members in developing an SI list to support student performance through fundamental STEM related courses.
   - On Thursday May 17, the Department chair updated the board of trustees with department annual activities, new program development (stackable manufacturing certificate programs that lead to a BS in advanced manufacturing), student engagement (UAV and Robotics competitions, conference, and scholarly activities), assessment & preparation for the 2019 ABET site visit, industry connection seminar series, and other department related issues.
   - On September 2018, the Department chair submitted the 2017-2018 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 Pathway Meeting:** On November 9, the Department chair and STEM Pathways Transfer Liaison met with Jody F. Popper Guidance Counselor of Robert F. Kennedy Community High School regarding enhancing program articulation between these two institutions. In this meeting the following items were discussed:
     - A group of RFK senior who are enrolling for MCE101 (1 credit, Introduction to Robotics) at Vaughn during spring (March to June 2019) and upon successful

completion with a grade of C or better, this course can be applied towards a Vaughn College Engineering degree program.

- A new engineering graphic course (2 credits, SolidWorks) will be added to the current articulation agreement to provide senior students with part and assembly design skills using 3D printing. Vaughn's STEM pathways Transfer Liaison will develop a new articulation agreement to include this additional course.
- STEM Programs: the Department chair and Vaughn's STEM pathways Liaison plan to organize a STEM workshop for RFK senior students during the spring semester at Vaughn.

❖ **Industry Advisory Meeting:** On Thursday, Dec 6, the Department chair organized a meeting with the Engineering and Technology Industry Advisory Board to discuss new changes to EAC and ETAC of ABET regarding Criterion 3, Student Learning Outcomes, and Criterion 5, curriculum. In this meeting he updated advisory members with department assessment process, self-study development, and preparation for 2019 ABET site visit. 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.

LABORATORIES UPGRADE AND ENHANCEMENT

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 2017-2018 academic year, the department completed purchase of the following laboratory equipment:

1. Instron material test system (Tensile tester - 5982 Model 5982 Materials Testing System), Price **$78,191**, Mechanical Testing lab.
2. CNC Lathe Machine (Okuma GENOS L200E-MY-EX 500 (14.08)), Price **$102,900**, CNC Machining Center
3. Coordinate Measuring Machine (CMM - Revolution "HB" 5.9.4 Shop Floor CMM (5-Axis)), Price **$79,900,** CNC Machining Center
4. CNC Stepcraft 2/D 840 Desktop Systems, Price **$10,396.58**, CNC Machining Center
5. 3 (model D45-01) Digilab 3D Printer, Price **$4,197**, 3D Prototyping Innovation Center
6. ProJet MJP 2500 Plus 3D Printer, Price **$50,650**, 3D Prototyping Innovation Center
7. Automation Sub-System lab equipment (IMS Processing, testing, handling, Storage, Routing, Buffering, and UniTrain Interfaces+ Experimenters, Price **$112,485.83**, Automation Lab.

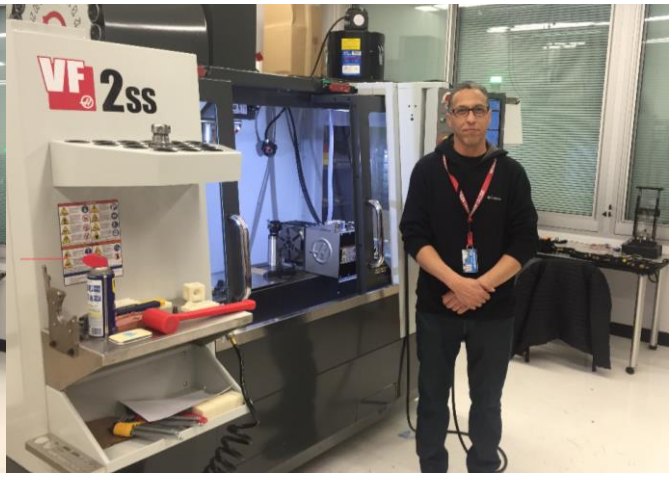
This laboratory equipment will allow Vaughn to provide students with practical STEM hands-on training in additive manufacturing, CNC machining, composite, and automation that is current with today's manufacturing industry standards.

- **NEW Machine Shop**

The renovation of the new CNC machine shop at Vaughn's Aviation Training Institute (ATI) building is in process and by mid-spring 2019 all CNC related equipment (HASS VF-2SS CNC milling and cutting machine, Okuma Genos lathe machine, Coordinate Measuring Machine

(CMM) for manufacturing part inspection) will be moved to its new location in the Astoria building.

Both faculty and students should be 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.



On Dec 17, 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 CNC manufacturing Lab Tech specialist. Besides his lab tech responsibility, he is hosting CNC workshops to familiarize students and club leaders (Robotics, UAV, and Automotive clubs) with the safe usage, operation, and manufacturing process of various CNC machines for their technical projects.

- **Robotics and Control System Laboratory**

This lab is used to teach laboratory courses such as MCE101 (Introduction to Robotics), ELE326 (Microprocessor), ELE350 (Control System), MCE420 (Mechatronics II-Robotics) and has dedicated seating to instruct 15-20 students. This lab maintains equipment related to control system, Intelitek robotics, microprocessor, and mobile robots.

- **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 academic year 2018, department added 3 (model D45-01) Digilab 3D Printer, and one ProJet MJP 2500 Plus 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.

- **Mechanical Testing Laboratory**

This lab is equipped with Measurement Group, Inc. strain measurement hardware and measuring devices for instructional capability in stress analysis. Students can perform basic experiments in plane stress, torsion, and bending to verify the basic equations in strength of materials. In fall 2015, the engineering and technology department purchased two desktop tensile machines and two furnaces for the Mechanical Testing Lab. This laboratory course complements lecture courses in solid mechanics concentration in our mechanical engineering program and provides our students with hands-on experiences in evaluating mechanical properties. This lab is equipped with a tensile machine, torsion machine, fatigue machine,

impact machine, hardness machine, vibration testing equipment, strain measurement hardware and devices for stress analysis. In academic year 2018, with the support of the new Title III grant, the department added an Instron material test system machine and also is planning to further enhance the current lab by adding equipment related to RAPTOR imaging flaw detector, and digital ultrasonic flaw detector machines.

- **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.

Autoclave

Oven for Composite Manufacturing

Vacuum bagging kit

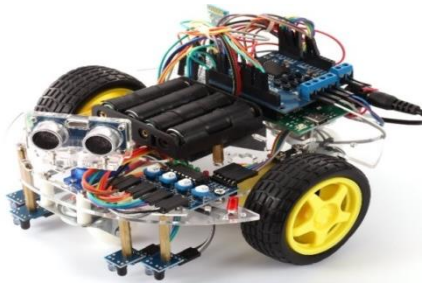
Phased array ultrasonic testing equipment (flaw detector)

Eddy current testing equipment

- **Electronics Laboratory**

The department of engineering and technology ensures that laboratories for all programs are adequately equipped with training stations, supplies, experimentation kits, general and special test equipment to ensure that student learning is enhanced in all courses through appropriate hands-on skills directly related to the current needs of the industry.

The department has recently acquired development kits for AVR ATMega328p microcontrollers. These kits include wide array of sensors such as temperature, shock, vibration, infrared, humidity, smoke, carbon monoxide, laser, LDR, passive mic, color recognizer, and a variety of output devices such as LCD displays, multicolor leds, servo motors with encoders, ultrasonic transmitter-receiver, laser emitter and DC motors. These development kits have been instrumental in helping students apply their knowledge of microcontrollers to Internet of things (IoT) solutions in remote controlling and remote autonomous sensing.



Additionally, the department has purchased several autonomous line-follower robot development kits that students use to design different types of rover systems. These rovers can be line-followers, sense-and-avoid, or all inclusive simultaneous localization and mapping (SLAM) bots by sensing the environment through ultrasonic distance measuring and LIDAR ranging. The department also utilizes Microchip PIC microcontroller evaluation boards and burn-in platforms.

Courses in DC circuits, AC circuits and Communication systems utilize LabVolt Facet line of trainer boards. Analog communications trainer boards are used to help students understand concepts of digital communications, pulse amplitude modulation (PAM) signal generation, demodulation, PAM time division multiplexing (TDM), pulse time modulated (PTM) signal demodulation and generation, pulse code modulation (PCM) generation and demodulation, signal time-division multiplexing, and Noise Channel Bandwidth.

Digital communication boards provide hands-on skills in encoding and decoding frequency shift keying (FSK) signal generation, asynchronous detection, synchronous detection, phase shift keying (PSK) signal generation and synchronous detection, amplitude shift keying (ASK) signal generation and asynchronous detection effects of noise on ASK and PSK and operation of an FSK and differential phase shift keying (DPSK) modem.

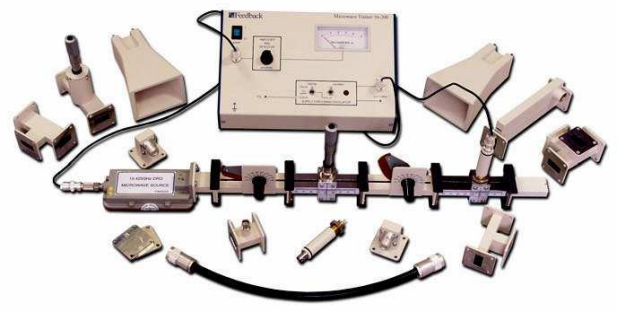
The Digital Signal Processor circuit board introduces students to the vast field of digital signal processing (DSP) and its applications. The board is designed around a modern DSP and includes all of the peripherals and accessories required to run multiple DSP applications.
Fundamentals of AC circuits board are used to help with concepts of magnetism, AC waveform

generation, AC amplitude measurements, current and impedance measuring, phase angle, series vs parallel circuits, inductive and capacitive reactance and impedance, relay transformer windings, mutual inductance, turns and voltage ratios, RC circuits, RC time constants and RC/RL Wave shapes.

The program also utilizes recently purchased FEEDBACK 56-200 microwave trainer systems that help students in measurement of frequency and wavelength, diode detector law, measurement of voltage standing wave ratio (VSWR), impedance matching and applications of typical waveguide components such as directional coupler, E-plane tee, H-plane tee, hybrid tee, waveguide to coaxial



transformer, and horn antennas as feed elements for radar reflectors, as well as microwave radio link transmit and receive antennas.



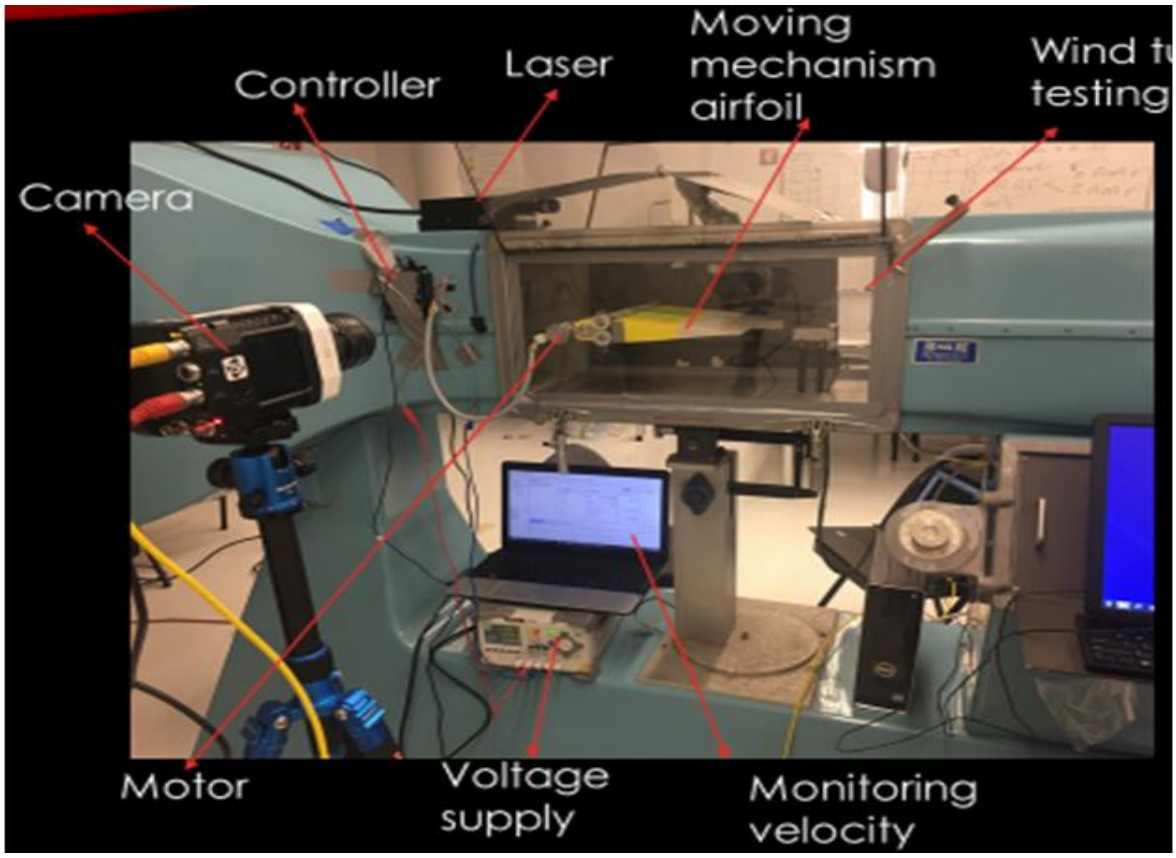
The department also recently replaced soldering stations with a set of six Hakko soldering and circuit rework stations from Technitools® and a surface-mount soldering and rework station in order to give students hands-on skills in soldering and desoldering in accordance with IPC-A-610 – Acceptability of Electronics Assemblies and FAA Advisory Circular 43.13 - Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair.

The program continues to utilize recently purchased function generators, high voltage power supplies, spectrum analyzers and oscilloscopes to enhance student hands-on skills in foundational concepts of DC circuits, AC circuits, electronic devices, digital electronics, communication systems, navigation systems, pulse systems and radar systems.

- **Thermo-fluid Laboratory**

This lab has dedicated seating to instruct 15-20 students, and students have the opportunity to conduct a wide range of experiments related to thermal and fluids sciences, such as measuring aerodynamic drag, liquids densities, hydrostatic pressure, Boyle-Marriott's law, surface tension of liquids, flows in liquids & gases, heat exchangers efficiencies and free and forced heat convection coefficients. This laboratory course complements lecture classes such as fluid mechanics, aerodynamics, and heat transfer.

In fall 2015, the engineering and technology department placed a purchase order for a High Speed Camera and CW laser; this equipment provides an important benefit to the thermo-fluid laboratory, and it will be used to complement the courses (MEE260-Aerodynamics, MEE360-Propulsion Power for Aircraft and Rocket Engines, EGR375-ThermoFluid) in our new mechanical engineering program. In fall 2016, the CAD import module has been added to COMSOL finite element package to allow students to build geometric model from any existing CAD software.



Industry Advisory Council

At Vaughn College, the industry advisory members have 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 a career or an internship opportunity 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's 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 2015–2016, faculty in the engineering and technology department participated in the following professional engagements and workshops:

Hossein Rahemi

1. On January 13, 2018, along with Vaughn's robotics team, we hosted the VEX High School regional robotics qualifier at Vaughn College. A total of 37 regional high schools from Queens, Brooklyn, Bronx, Nassau, and Suffolk counties attended the January state qualifier VEX Robotics Competition at Vaughn College. An alliance of KG Computech and The Harvey School won the tournament championship, while a team from Jericho High School won the "Excellence" Award, and KG Computech won "Robot Skills." Tournament champions, "Excellence" Award, and "Robot Skills" Winner qualified to participate in the New York State VEX Championship.
2. On January 27, 2018, along with Vaughn's robotics team, we hosted the VEX U regional qualifier at Vaughn College. A total of 13 college teams participated in this event and Vaughn's robotics team won the first place Skills' award, tournament Champion award, and a qualification to participate in the 2018 VEX U World Robotics Championship.
3. On March 2, 2018, as an advisor to Vaughn's robotics team, the Chair participated at the West Virginia at the Fairmount State University 2018 VEX U Robotics Regional Tournament. A total of 19 colleges and universities participated in the event and 2nd Vaughn's robotics team VCAT2 won both "Finalist" and "Robot Skills" championship awards which qualifies the VCAT2 team to participate in the 2018 VEX U world championship.
4. In spring 2018, 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.
5. He published the tenth 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 2017).

6. The Chair hosted the tenth Annual Vaughn College Technology Day Conference on April 20, 2018. At the morning session, he introduced the advisory members to department's accreditation process and preparation for ABET 2019, the contents of the department activities, new program development, laboratory development & enhancement, faculty and students' professional development, students' involvement in robotics and UAV competitions and their accomplishment. The afternoon session was devoted to student capstone research project presentations and the poster session. The participants included industry advisory members from Sikorsky Aircraft Corporation, Bakery Innovative Technology, Corning Incorporated, CPI Aero, Pavon Manufacturing Group, NASA Education Department, Defense Contract Management Agency (DCMA), Honeywell, U.S. Didactic, Con-Edison, FAA, jetBlue, Dassault Systems, Kedrion Biopharma, City Tech CUNY, and Queensborough Community College (QCC).
7. As a PD of the NSF S-STEM grant ($575,000 funded by NSF), he submitted an extension for NSF S-STEM grant until May 2018 and he monitored NSF learning community activities and engaged the 4th year NSF scholarship recipients in professional engagements related to conference participation, conference poster competitions, and Robotics/UAV club activities & competitions.
8. From spring to fall 2018, he 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.
9. On May 17, 2018, the engineering and technology department chair presented an update on the department and the new title III STEM grant activities to the Academic Policy Committee of the Board of Trustees. The presentation included an update on the 10th annual technology day conference and advisory meeting, tenth annual Vaughn College Journal of Engineering and Technology, VEX U robotics world championship competition, Vaughn's 3rd International Drone (May5, 2018), Vaughn's UAV team success as champion of 2018 Micro Air Vehicle competition of American Helicopter Society (May 14, 2018), programs assessment and preparation for the ABET 2019, ME & EE enrollment, new faculty, laboratories development, and updates on: the 3rd annual manufacturing day conference, the industry connection seminar series, the engineering seminar series, and student participation in professional activities and technical competitions.
10. He participated as one of the Vaughn's robotics team advisers in the 2018 VEX U World Robotics College Championship. From April 25-28, 85 national and international universities and colleges received an invitation to participate in the 2018 VEX U World Championship in Louisville, Kentucky at the Freedom Expo Center. Invitation to the VEX U Robotics World championship is only granted to a team that is a tournament champion or 'Excellence' award recipient of a regional competition. Vaughn's Robotics team was 2018 tournament champion of the international Mexican competition (the Torneo VEX-Reeduca de la Zona Noreste 2017-2018 VEX in the Zone Challenge competition in the American School of Tampico, Tamaulipas, Mexico), tournament champion of the of Vaughn College

Regional Robotics Competition, and recipient of the 'Excellence' Award in theWest Virginia regional Robotics Competition—which qualified two Vaughn's teams to participate in the 2018 VEX U World Championship. For the fifth year in a row, Vaughn's robotics team was able to advance to the playoff round of the VEX U World Championship. During Thursday, Friday, and Saturday qualifying matches, Vaughn's team competed against 10 teams and they won seven out of the ten matches and advanced to the Saturday afternoon playoff round. During single elimination of playoff round, the top sixteen teams competed, and Vaughn's team defeated a top ranking team from Mexico (number one "Innovate" division) and advanced to the quarter-final in a close scoring match which they lost to a team from Mason

11. The Chair submitted the third 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 2018. Every September an annual report needs to be submitted to the NYSED until the department receives EAC- ABET accreditation for both of these programs.
12. On Saturday May 5, 2018, the engineering department in collaboration with UAV team organized and hosted several drone workshops such as CAD Modeling of Quadcopters, Build a Drone, and Programming with Python in order to celebrate International Drone Day. This event allowed visitors and high school students to design, build, and test their own drones in the netted flying arena of the college hangar.
13. 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 and the University of Maryland to participate in the 6th annual Micro Air Vehicle (MAV) student challenge competition in Phoenix Convention Center on May 14, 2018. Vaughn's UAV team developed two drones to compete in both manual and autonomous categories. Vaughn's remote control team was the only team that completed three flawless successful runs within the 10 minutes permitted time. For the autonomous session, only Vaughn's autonomous team was able to fly their drone with vertical takeoff and partially hovering around the field. For the 2018 Micro Air Vehicle competition, judges from aerospace industries evaluated the teams' performance for both the remote and autonomous control categories. Vaughn's UAV team received the highest score in both categories. As the 2018 winners of the Micro Air Vehicle competition, Vaughn's remote control team received "Best Remotely-Controlled Target Search" award (first place award) with a $2000 check. Vaughn's autonomous team was the only team that for the past three years was able to have vertical take-off and partially complete the autonomous category and for that they received the "Honorable Mention" award with a $1000 check.
14. On June 25, 2018, the Chair participated with other Vaughn's faculty in the 2018 ASEE annual conference and presented a paper entitled "**Enhancing Student Learning Outcomes through the Freshmen Summer Engineering Experience (SEE-STEM) Program**." Their paper detailed the process for the summer bridge program in preparing students for the core courses within engineering disciplines as well as enhancing students' hands-on, computational, programming, communication, teamwork, and problem solving learning outcomes. In the morning session, along with Vaughn's NSF learning community faculty, they presented their NSF project "**Increasing Student Enrollment and Achievement in Engineering and Engineering Technology**." during the NSF Grantees Poster Session of ASEE annual conference. Their poster detailed the process for the NSF STEM Scholarship

program at Vaughn College of Aeronautics and Technology from 2012-2017. The Project is focused on increasing enrollment and retention of talented students in STEM undergraduate education.

15. From July 17-20, as an advisor to Vaughn's student projects and as a Liaison of LACCEI board, the Chair participated in LACCEI 2018 Conference in in Lima, Peru. On Thursday July 19, two of our student team papers "**Smart Autonomous Robot Design for VEX U Challenge - In the Zone"** by Niki Taheri, Atif Saeed and "**Development Process of a Smart UAV for Autonomous Target Detection"** by Utsav Shah, Ryan Tang Dan were selected and presented as finalists for the student paper session of LACCEI 2018. Out of ten finalist papers, Vaughn's student paper by Niki Taheri and Atif Saeed received the 3rd place award in this session.
16. Hosting Vaughn's 4th Annual Manufacturing Day Conference on October 19, 2018 to celebrate National Manufacturing Month, we invited three industry leaders and two faculty members to address invited guests and the Vaughn community about manufacturing innovation in the area of additive manufacturing, composite, 3D printing, CNC machining and manufacturing process. In a parallel session, from 11 am to 2:00 pm, Vaughn's UAV and Robotics clubs organized and hosted workshops on building a drone, robotics design, and autonomous programming for the high school students from Freeport, Bayside, Thomas Edison, ESBOCES Engineering, and West Islip high schools

    CNC Machining and Manufacturing Certificate program: As Project Director of HIS-STEM title III grant and with input of CNC and 3D curriculum developer, the department Chair developed and submitted this certificate program to the NYSED for their review and approval. This certificate program has five courses totaling 15 credits and 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. Five courses toward this certificate program are as follows:

    1. **CNC100-Precision Measurement for CNC:** 3 credits, 2 lecture hour, 1 lab hour (3 contact lab hours) – Semester 1
    2. **CNC201-Computer Numerical Control (CNC) Manufacturing I:** 3 credits, 2 lecture hour, 1 lab hour (3 contact lab hours) – Semester 1
    3. **CNC202-CNC G code Programming Fundamental:** 3 credits, 2 lecture hour, 1 lab hour (3 contact lab hours) – Semester 2
    4. **CNC203-Computer Numerical Control (CNC) Manufacturing II2:** 3 credits, 2 lecture hour, 1 lab hour (3 contact lab hours) – Semester 2
    5. **CNC204-CNC CAM Programming:** 3 credits, 2 lecture hour, 1 lab hour (3 contact lab hours) – Semester 2
17. **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:

    1. My Dream Job**,** Ms. Leonie Barden, Systems Engineers at Boeing, September 20, 2018.

2. Electronics Design for Aerospace**,** Mr. Carlo Asaro, Aircraft Avionics Systems Engineer with Sikorsky, a Lockheed Martin Company, Nov 2, 2018.
3. An Overview of the NASA, STEM Workforce Challenges, and NASA's Internship Programs, Mr. Matthew Pearce, NASA Education Programs Specialist, Dec 4, 2018.
4. Engineering in Energy Services - A Summer Internship Project at Con Edison, Mr. Mohammad Fahim Shahriar, MET Senior Student, December 7, 2018.
5. Gulfstream Aerospace Summer Internship Program, Mr. Darwing Espinal, MET Senior Student, December 13, 2018.
6. eVTOL technology (electric powered helicopters), Mr. Laurent Ducruet, Thales Avionics, April 2, 2019

12. **Supplemental Instructors (SI):** In an effort to increase learning effectiveness, as part of the Hispanic-Serving Institution HSI STEM grant, the Supplemental Instructor (SI) program was developed to further enhance and improve student understanding through the fundamental courses in engineering and engineering technology programs. In fall 2018, 15 talented SIs, who have already completed the fundamental courses, were selected to sit-in on designated courses, with instructors, to serve as Supplemental Instructors. The SIs are assigned the tasks of reviewing class lectures, conducting problem solving sessions and communicating with the faculty members about areas where students need reinforcement in order to be successful in the course.
18. On October 17, 2018, Dr. Rahemi presented department activities, development process of programs' self-study reports, and preparation for the ABET 2019 to the Academic Policy Committee of the Board of Trustees; these were as follows:
    - Update on hosting the fourth Annual Manufacturing Day Conference on Friday October 19, 2018.
    - Update on UAV club accomplishment as champion of 6th Annual Micro Air Vehicle Student Challenge of 2018 American Helicopter Society.
    - Update on HSI-STEM title III grant activities including information regarding laboratory development, development of manufacturing certificate programs, meeting with staff and manufacturing curriculum faculty, equipment and facility renovation.
    - Update on 1 through 8 criterions for ABET self-study reports.
    - Update on documented process by which the program objectives and student outcomes are periodically evaluated.
    - Update on faculty course assessment report for assessing student outcomes through assigned course tasks (a direct measure).
    - Update on direct measure of student outcomes assessment through internship and employer supervisor surveys.
    - Update on indirect student outcome assessment using exit and alumni surveys.
    - Update on analysis of student outcomes and development & implementation of corrective actions as part of continuous improvement based on constituents' feedbacks.

19. On Thursday, Dec 6, 2018, Dr. Rahemi organized a meeting with the Engineering and Technology Industry Advisory Board to discuss new changes to EAC and ETAC of ABET regarding Criterion 3, Student Learning Outcomes, and Criterion 5, curriculum. In this meeting he updated advisory members with the department assessment process, self-study development, and preparation for 2019 ABET site visit. 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 following items regarding changes to ABET's student outcomes and curriculum and department assessment and preparation for the 2019 ABET site visit:

- Update and mapping of the new EAC-ABET student outcomes (1 through 7 student outcomes) to current a - k student outcomes for BS engineering programs.
    - Update and mapping of the new ETAC-ABET student outcomes (1 through 5 student outcomes) to current a - k student outcomes for AAS and BS engineering technology programs.
    - Development process of programs' Self-Study report based on ABET criterion 1 through 8 of program requirements.
    - List of documented processes by which the PEOs and learning outcomes are periodically evaluated (FCARs, Laboratory performance, Capstone, internship survey, employer survey, exit survey, and alumni survey).
    - An overview of program objectives and processes through which the PEOs are determined and revised.
    - A graphical representation of department's assessment process and its feedback loop for continuous improvement based on assessment motivated and constituents motivated action plans.

20. From November 21-23, 2018, Dr. Rahemi and seven members of Vaughn's Robotics club traveled to Mexico to participate in the Signature VEX U Challenge competition in the Univeredad Politecnica De Quintana Roo, Cancun, Mexico. **The team finished first place for the robotics skills (Programming and Driving Skills) champion category and second place overall in the competition**. For past four years, Vaughn's robotics team members consistently demonstrated persistence and drive in order to attain their title as champions and as top competitors in Mexico's VEX U Robotics competitions.
21. <u>STEM Outreach Activities</u>
    - On Wednesday October 24, 2018, attended with Vaughn's faculty, students, and staff the Long Island STEM HUB careers Conversations at the Cradle of Aviation Museum in Garden City.
    - On Friday November 16, 2018, hosted a day of STEM workshop for 27 Hillcrest high school students and their mentors at Vaughn College.
    - On Friday March 8, 2019, hosted a day STEM pathway workshop for community colleges. This full-day event introduces participants from Suffolk, Bergen, Passaic, Queensborough, and Bronx community colleges to the following STEM workshops:
        - **Welcome:** A presentation of Vaughn College's program offerings and student involvement in professional and scholarly activities
        - **3D Printing and Additive Manufacturing Workshop:** Introduction to 3D and surface modeling using Solid Works and CATIA with 3D additive manufacturing processes.

- **Avionics Workshop:** Introduction to avionics with hands-on experiences related to aircraft radar, communication and navigation systems
- **CNC Workshop:** Introduction to HASS VF-2SS CNC milling and cutting machine and manufacturing processes.
- **Build A Drone Workshop:** Introduction to building and manufacturing processes of flying robots.
- **Robotics Workshop:** Introduction to structural design processes necessary for creating reliable and durable robots for robotic competitions.

Amir Elzawawy

1. On January 2019, worked with students in UAV club to submit gate 1 paper to participate in Micro-UAV competition at AHS annual forum 75 in May 13-16 in Philadelphia, PA.
2. On December 12, attended UAS training at Quanser Facility in Markham, Canada on the equipment that will be used in the new UAS laboratory that is planned to be established in 2019.
3. On October 26th, invited as a panelist on Engineering, Architecture & Robotics Commission to review Bronx Aerospace High School Curriculum.
4. On June 26th, as a co-author presented the conference paper titled "Enhancing Students' Learning Outcomes through Freshman Summer Engineering Experience (SEE) Programs" as part of ASEE annual conference Salt Lake City, UT.
5. Participated and presented a poster "Increasing Student Enrollment and Achievement in Engineering and Engineering Technology." along with Vaughn's NSF learning community faculty during the NSF Grantees Poster Session of ASEE annual conference, Salt Lake City, UT from June 24 to 27.
6. Advised students to publish and present a conference paper, titled" Development Process of a Smart UAV for Autonomous Target Detection" for the international student paper competition in the 2018 LACCEI International Multi-Conference of Engineering, Education and Technology. The paper was presented during the conference on July 18-20, 2019 in Lima, Peru.
7. Attended NSF Grant Conference, June 4th and 5th, Detroit, MI. The conference is an opportunity to learn about NSF grants, the merit review process, and the reporting requirements.
8. On May 14th, 2018, participated with two teams from UAV club at Vaughn in Micro-UAV competition in Phoenix AZ. Vaughn UAV won the first place in the manual competition and won the only honorary award that was given to a team in the autonomous competition.
9. May 5th, 2018 coordinated the International Drone Day (IDD) that was held on Vaughn College campus. The event is open for the public and was organized by UAV club at Vaughn College.
10. Organized NSF-STEM poster session as part of Vaughn College Annual Technology Day, April 20th, 2018.
11. Continued working with UAV club on the club activities including the upcoming semester activities, evaluated events and workshops given to high school students at Vaughn College's Manufacturing Day.
12. Advised and mentored students to develop research journal papers for VCJET 2018. The projects were presented in the afternoon session of Tenth Annual Vaughn College Technology Day Conference on April 20, 2018.

Shouling He

1. Served as a program coordinator of Mechatronics Engineering (MCE) Program; evaluated students' qualifications for the program applications; assessed department exit surveys, alumni surveys, internship supervisor surveys and employer surveys; developed and collected faculty course assessments and written the program assessment report for the MCE program; and prepared documents for Middle States Accreditation board visiting in April 2017 and ABET board visiting in Fall 2019.
2. Worked on faculty course assessment cards (FCARs) and developed 12 FCARs to evaluate the courses taught in fall 2017.
3. Advisor for four groups of student capstone projects with the presentation at 2018 VCATD Conference and the publications in 2018 VCJET (2^{st}-3^{rd} places in paper competition.) One group presented a project paper at 2018 ASEE annual conference and another group presented their project at 2018 LACCEI conference.
4. Advisor for one student project entitled "Team Cleaning Robots." during the Capstone Projects session of 2018 ASEE Annual Conference, in Salt Lake City, Utah, June 24-27, 2018.
5. Participated 2018 ASEE Annual Conference and presented the paper "Multi-sensors for Robot Teaching Using Raspberry PI and VEX Robotics Construction Kits." during the Automation in Manufacturing session of 2018 ASEE Annual Conference, in Salt Lake City, Utah, June 24-27, 2018.
1. Participated three-Day Power engineering Workshop given by LN Academy, Ralf Linnertz: Nov 12-14, 2018. Asynchronous and DC motors; Line-Commuted converters; Self-Commuted Converter circuits; Frequency Converters; Synchronous machines and manual operated synchronization; Compensation of reactive power (Manual and Automatic).
6. Participated the NSF-RET Program held at Texas A&M University and worked a master teacher for 6 weeks, wrote the report and presentation entitled "Multi-Sensors for Robot Teaming using Raspberry Pi and VEX Robotics Construction Kit;" the paper has been accepted by ASEE 2018 Annual Conference, June 26-28, 2018, Salty Lake, UT.
7. Presented the educational research with the title of "Development of Teaming Robots for Engineering Design Education – Cross-platform System" at the 2018 NSF-RET Program Workshop, March 15, 2018, TAMU, College Station, Texas.
8. Wrote an educational research paper, "Teaching Linux and ROS for Mechatronics Engineering Students," the abstract of which has been accepted by 2018 Frontiers in Education – "Foster Innovation through Diversity," October 3-6, 2018, San Jose, CA,
9. Worked as a club advisor at the 2018 Society of Women Engineers (SWE) Annual Conference, October 17-20, 2018, Minneapolis, Minnesota, assisting SWE Vaughn Chapter Students in holding a workshop at the world's largest conference for women in engineering, and helped female students with job interview process.
10. Worked as a club advisor to help the SWE club to gain $5000 grant from Con Edison Company for SWE STEAM education programs at Vaughn College, and advised students for workshop organizations and club activities; helped the club for the tour of RCM Technology facility and worked as an advisor for the partnership with the Physics Department of Queens Community College for the development of data acquisition board for ray detectors and data analysis.

11. Worked as a mentor for three NSF-STEM Scholarship groups (one in 2017 and two in 2018) in their research. One student won the first award in the poster section at the 2017 Vaughn College Annual Technology Day (VCATD) Conference.
12. Worked with students on an educational research paper "Development Process of a Smart UAV for Autonomous Target Detection." This paper was presented at the 2018 LACCEI Conference.
13. Worked to improve the course, MCE420, Autonomous Mobile Robots with the ROS operating system and the basic principle of mobile robot mapping and localization so that the students in Mechatronics Engineering program can learn current knowledge in the area of Robotics.
14. Improved the course, ELE326/ELE326L, Microprocessors, by adding the basic concepts of GPUs and Computer Vision. Particularly, the course projects allowed students to learn new knowledge in microprocessors and to share their understandings at the presentation thus enhancing their capacity for life-long learning.
15. Worked as a faculty-member at the open house in the spring and fall 2018, introducing the Mechatronics Engineering program and the SWE Vaughn College Chapter.

Yougashwar Budhoo

1. Advised students of the SHPE club at Vaughn College.
2. Developed and taught MEE 390, mechanics of composite materials; a new course in the mechanical engineering curriculum
3. On May 14, 2018, attended a five-day course on "Advanced Composite Manufacture" at Abaris training facility in Reno Nevada.
4. Attended 2018 Dassault systems solution 'Community of Experts' Annual Experience and TechniFair and advised students with their project development and presentation for the poster session of this annual gathering event (April 15 to 18, 2018).
5. Conference Paper: Amir Elzawawy, Hossein Rahemi, Margaret Ducharme, Yougashwar Budhoo, Increasing Student Enrollment and Achievement in Engineering and Engineering Technology, 2018 ASEE Annual Conference, Salt Lake City, UT,
6. Conference Paper: Hossein Rahemi, Amie Elzawawy, Yougashwar Budhoo, Advanced Manufacturing Engineering Technology Program: A Program that prepares Graduates for Today's Manufacturing Industry, 2018 ASEE Annual Conference, Salt Lake City, UT,
7. Adviser for students' poster presentation entitled "Foldable stool" " at the LACCEI 2018 Conference, in Lima, Peru, 2018
8. Presented a certificate course on Mechanics of composite materials for engineers at Motor Sich engineering company in Ukraine, March 2018
9. Completed course and program level assessment for courses in the Mechanical Engineering Technology (MET) Program.
10. Distributed, collected, and analyzed surveys (exit, alumni, internship, and employer) from our students, alumni and employers for 2017.

Douglas Jahnke

1. Became the faculty advisor for the Society of Automotive Engineers (SAE) chapter at Vaughn College
2. Served on Student Retention Committee to develop ideas to improve student retention at Vaughn College. 2018 – present

3. Served as co-chair of Marketing and Enrollment working group for Vaughn College's strategic planning initiative. 2018 – present
4. Attended Advanced Composite Structures: Fabrication & Damage Repair-Phase 1, Abaris Training, Reno, Nevada, January 7-11, 2019
5. Attended Fall 2018 National Science Foundation (NSF) Grants Conference in New Orleans, Louisiana, November 8-9, 2018
6. Attended SME Smart Manufacturing Seminar Series: Metal Additive Manufacturing Developments, Philadelphia, Pennsylvania, October 24, 2018
7. 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.
8. Publication: Jahnke, D., Azadeh-Ranjbar, V., Yildiz, S., and Andreopoulos, Y., 2017, "Energy Exchange in Coupled Interactions between a Shock Wave and Metallic Plates," International Journal of Impact Engineering, 106, pp. 86–102.
9. Publication: Hashemi, S., Jahnke, D., Sadegh, A. M., and Andreopoulos, Y., 2016, "The Effect of Shock Waves on Brain Blood Pressure; Experimental and Computational Studies," International Journal of Experimental and Computational Biomechanics, 4(1), pp. 59–78.
10. Conference paper: S. Yildiz, D. Shaffren, D. Jahnke, F. Delale, and Y. Andreopoulos, 2016, Characterization of Adhesive Joints Under Shock-Wave Loading, ASME 2016 International Mechanical Engineering Congress and Exposition, Phoenix, AZ, November 11-17, 2016
11. Conference paper: D. Jahnke, V. Azadeh-Ranjbar, and Y. Andreopoulos, 2016, Composite Plate Response to Shock Wave Loading, SEM XIII International Congress, Orlando, FL, June 6-9, 2016

Mohammed Benalla

2. Advised and mentored multiple teams of students to develop research journal papers for VCJET 2019. The projects will be presented in the afternoon session of 11th Annual Vaughn College Technology Day Conference, April 2019.
3. Reviewer and Chair of Biomechanics session, 35th Southern Biomedical Engineering Conference, Hattiesburg, MS, February 22-24, 2019
4. Served on a panel to review and discuss proposal submitted to the NSF S-STEM program, Fall 2018.
5. Oral presentation, ASEE 125th Annual Conference in Salt Lake City, UT from June 24th to 27th, 2018
6. Spring 2019, Development of a new electrical and mechatronic engineering program course titled "Biomedical Engineering Instrumentation", the course will be offered on fall 2019.
7. Reviewer and Chair of Biomechanics session, 34th Southern Biomedical Engineering Conference, Holiday Inn, Charlotte NC, March 8-10, 2018.
8. Reviewer and Chair of Biomechanics session, Thirty-fifth Southern Biomedical Engineering Conference, Gulfport Mississippi, March 8 - 10, 2018.
9. Power engineering workshop with LN® Equipment given by LN Academy, Ralf Linnertz: Nov 12-14, 2018. Asynchronous and DC motors; Line-Commuted converters; Self-Commuted Converter circuits; Frequency Converters; Synchronous machines and manual operated synchronization; Compensation of reactive power (Manual and Automatic).
10. Served as a member of a search committee to hire a new faculty for the electrical major.

11. Attended NSF Grant Proposal Writing training, Colombia University, NY, January 15th to March 15th, 2018.
12. Participated at NSF Spring Grant Conference, Detroit, MI, June 4 - 5, 2018,
13. Participated at the open house during the fall and spring 2018, introducing the Electrical Engineering program and power system lab.
1. Participated at Vaughn's 4th Annual Manufacturing Day, a one-day event for networking with industrial leaders in aviation and manufacturing. October 19, 2018
14. Judged 4th annual regional Vaughn's college high school robotics competition for on January 13, 2018 (Spring) and November 27, 2018 (Fall).
15. Participated at NSF Winter Grant Conference, New Orleans, LA, November 8 - 9, 2018, Attended NSF Grant Proposal Writing online training January 15th, 2018 through March 15th, 2018.
2. Served as a future program coordinator of Electrical Engineering (ELE) Program; evaluated students' qualifications for the program and reviewed their transcript; worked with Dr. He on improving the program curriculum and helped on preparing some documents for ABET board visiting in Fall 2019.
3. Worked on faculty course assessment cards (FCARs) and developed FCARs to evaluate all the courses that I taught.

Papers 2018- 2019

1. MAKER: Early Learning Braille Block Language System, N. Taheri, A. Saeed, M. Benalla, 126th ASEE Annual Conference & Exposition, Tampa, Florida, June 15 - 19, 2019 (in progress).
2. Walking Wise: Smart Walking Cane for the Blind and Visually Impaired", R. Ramalal, j. James, M. BenallaLACCEI, Jamaica 2019, In progress.
3. Brain controlled Prosthetic Arm, Sam Maddaloni, G. Davis, and R. Mohammed, A.Said and M. Benalla, 35th Southern Biomedical Engineering Conference, Hattiesburg, MS, February 22-24, 2019.
4. Motion Tracking Robotic Arm, A. Ali, M. Botros, and M.Benalla, 35th Southern Biomedical Engineering Conference, Hattiesburg, MS, February 22-24, 2019.
5. Student Community Project to Design of a Mini Golf Course for Leesville City – LA, M. Benalla, 125th ASEE Annual Conference & Exposition, Salt Lake City, Utah, June 24 - 27, 2018.

Miguel A. Bustamante

1. Engineering Without Boarder (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.
2. EWB-USA Water testing workshop-Jan 19, 2019. One day training on how to take measurements of water contaminant and proper record data obtain from the optical sensors. There was also a Biological testing for e-coli contaminants on water sources. We also learn on how not to cross contaminate samples.
3. IEEE LI Section Power Electronics Symposium-Trends in Power Electronics Thursday November 8, 2018. Advances in GaN Technology; Designing SMPS in the High di/dt Era; Challenges of Three-Phase Power Factor Correction; Power Simulation Using LT Power

CAD; Stress-Free Electrical Safety for Power Designers; Power Conversion Solutions for Emerging Energy; EMC Inductors and Filtering.

4. Power Engineering with LN® Equipment given by LN Academy, Ralf Linnertz: Nov 12-14, 2018. Asynchronous and DC motors; Line-Commuted converters; Self-Commuted Converter circuits; Frequency Converters; Synchronous machines and manual operated synchronization; Compensation of reactive power (Manual and Automatic).
5. Vaughn College Engineering and Technology Department 4th Annual Manufacturing Day Conference October 19, 2018; "Evolution of Sikorsky Rotor Craft Development and my Journey to a Chief Engineer's Role" Talk by Mr. Richard B Brown Lockheed Martin, Sikorsky Aircraft: "Designing the Heat Tiles for the Space Shuttle" Talk by Ms. Sari Alyson Gerb Dassault Systèmes; "Manufacturing with a twist, a Big Data twist" Talk by Mr. Marvin Blackman GE Power; "Computer Graphic Modeling and Additive Manufacturing" Talk by Prof. Manuel Jesus ; "Damage Evaluation in Composite Materials Certificate Program" Talk by Dr. Yougashwar Budhoo
6. Advance Science Research Center, the Graduate Center City University of New York Nanofabrication Workshop: An Introduction to Utilizing Nanotechnology Workshop on Nano Fabrication November 9-10 2017 at the CUNY ASRC. *Lectures given by Dr. Jacob Trevino: O*n the fundamental processes for nanofabrication and an introduction to device applications and technologies. On fabrication tools and techniques including. Cleanroom safety training: A cleanroom orientation before stepping into the cleanroom, do's and don'ts. Fabrication demos in the cleanroom, including lithography, etch, deposition and metrology. Additional nanofabrication.

Sundari Ramabhotla

1. Faculty Advisor of IEEE at Vaughn College (March 2018 – Present)
2. Participant in Leaning Community in Engineering & Technology department, Vaughn College, January 2018 - Present.
3. Participated in the Smart Grid, power systems and power electronics lab training along with LabSoft (Lucas Nülle) at Vaughn College, November 12th – 14th, 2018.
4. Selected as the Faculty Super Users of Starfish during Launch Semester Report Spring 2018.
5. Attended Hobsons Summer Institute – Starfish Conference held at Palm Desert, CA, July 16th – 18th, 2018.
    - To strengthen student success in academic planning, course sequencing and careers using Starfish conference learning tool.
    - Starfish's academic planning tools to match students with degree plans that align with their goals and optimize their progress to completion.
    - To optimize student mentorship, optimizing student outreach, campus culture change, etc.
    - Faculty Committee member for evaluating the Final Degree Projects for Engineering and Technology students (Spring 2018 & Fall 2018).
6. Attendee at Women in Aviation 2nd meeting at Vaughn College, February 2018.
7. Attended Industry Connection Seminar Series for Spring & Fall 2018.
8. Faculty Committee member for evaluating the Final Degree Projects for Engineering and Technology students (Spring 2018 & Fall 2018).

9. Attended Open House for undergraduate students at Vaughn College during Spring and Fall 2018.

Peer Review

10. **Reviewer of Conferences and Journals** in the area of microgrids, power systems, electrical distribution, power electronics, etc.

Professional Memberships

11. **Institute of Electrical and Electronics Engineers** (IEEE)
    - Faculty Advisor (2018 – Present)
    - IEEE Member, Young Professional Member (2014 - Present)
12. **Society of Women Engineers** (SWE) (2018 – Present)
    - Life Member, Peer – Peer Mentor, Scholarship Reviewer for SWE Scholarship Program
    - Academic Leadership for Women in Engineering (ALWE) 2018 Grant Award supported by National Science Foundation and Henry Luce Foundation, Inc. to attend the ALWE 2018/WE18 in Minneapolis, MN on October 18th – 20th, 2018.

Outreach and Diversity

13. Presenter and Volunteer in the "***Invent It Build It 2018***", ALWE 2018/WE18 in Minneapolis, MN on October 18th – 20th, 2018.

Manuel Jesus

1. Attended Bronx NYC Public School STEM day and presented career options to students (April 2017)
2. Printed 3D models for the Robotics club and other Vaughn College students using the Fortus 250mc 3d Printer and Form 2 printers. (Ongoing)
3. Taught Catia Advanced Surface and Shape Design Course, Ascenbridge Solutions (June 2017)
4. Taught HASS CNC Machine Operation and Tool Setting, HASS HFO Allendale Machinery, (August 2017)
5. Worked as a faculty instructor for 2017 Summer Engineering Experience (SEE), taught students CAM and additive manufacturing.
6. Presented at Vaughn College Manufacturing Day Event (October 2017)
7. Attended Long Island Manufacturing Association Meeting (August 2017)
8. Attended "Character Design For Video Games and VR," Game Art Institute, Los Angles (May 2017)
9. Attended "Character Sculpting ZBrush," Game Art Institute, Los Angles (June 2017)
10. Attended "3-D Character and Creature Design," Game Art Institute, Los Angles (August 2017)
11. Attended ICEM Surf Class A Surfacing Fundamentals, BETA CAE Systems (Nov 2017)
12. Developed and taught Zion "Cradles to Careers" SolidWorks STEM Middle School outreach program (Dec 2017)
13. Judged VEX Robotics Regional High School Competition, (Jan 2018)
14. Ongoing researcher and developer of CNC and 3D printing related labs. (Jan, 2018)
15. Attended Mastercam Workshop (April, 2017)

Khalid Mouaouya

1. Participated In ASEE2018 Annual Conference and Exhibition, Salt Lake City, UT, June 24 to 27.
2. Participated in VEX Robotics Middle & High School competition as a Judge (January 2018 & February 2019)
3. Participated with Vaughn's Robotics team in in the Signature Mexico's VEX U Reeduca Robotics Challenge competition in the Univeredad Politecnica De Quintana Roo, Cancun, Mexico, November 21-23, 2018.
4. Participated in all Vaughn's spring and fall 2018 Industry Connection Seminar Series, and Engineering Seminar Series.
5. Participated in the 4th annual Vaughn Manufacturing Day conference on Oct. 19, 2018.
6. Advised Engineers Without Borders (EBR) club, fall 2015-present.
7. Attended Open House for undergraduate students at Vaughn College during spring and fall 2018, and presented engineering and engineering technology programs to prospective students and parents.

Ghania Benbelkacem

1. Member of American Society of Rheology. ASME and ASAA Member. Reviewer for Journal of Rheology. Holds CIES Higher Education Teaching Certificate (France).
2. Attended the 18th International Materials Research Congress, Mexico, August 2019.
3. 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.
4. Involved with organizing "Path to STEM workshop" March 19th, 2019.
5. Hosting "STEM day" for high school girls who are visiting Vaughn College to promote future female students. 2019
6. Served as a member of the Judge committee for the Robotics competition hosted by Vaughn College, February 9th 2019.
7. Involved with Vaughn college clubs: Society of Women Engineers, Engineers Without borders and VCAT Motorsport. 2019
8. Journal Publications [Solid obstacles can reduce hydrodynamic loading during water entry]. Accepted June 28th, 2018. Physical Review Fluids.
9. Research Scientist at Tandon school of Engineering - NYU, Office of Naval Research Grant N00014-10-1-0988 working on fluid-structure interactions "Ice - induced impact loading on wedges". 2018.
10. Advised undergraduate students for their research project at NYU – Tandon School of Engineering. Summer 2018.
11. Actively participated in OpenLab projects to support and to promote students and faculty members in the intellectual and social life. City University of New York – City College of Technology, 2018
12. Attended Multiple Research Seminars at New York University – Tandon School of Engineering. 2018.
13. Attended trainings and teaching workshops at New York University – Tandon School of Engineering from 2018.
14. Developed CAD courses for continuing education at Hostos College. 2018.

Mudassar Minhas

1. Represented Vaughn College at Passaic County Community College for STEM Makerspace event (Feb 2019)
2. Represented Vaughn College at Borough of Manhattan Community College for Engineering Science Workshop (Oct 2018)
3. Earned Project Management Professional Credential (Jul 2018)
4. Prepared a complete list of concentration courses and course syllabi for MBA in Engineering Management (Jul 2018)
5. ASQ/ANSI/ISO 9001:2015 Quality Management System Auditor Course by RIGCERT Inc., Feb 12, 2018
6. Completed Project Management Professional (PMP) Exam Prep course for the PMP Exam - 35 Contact Hours from PMI REP #4082 (Dec 2017 – Jan 2018)
7. Served as Chair for committee on "Planning Resources Allocation and Institutional Renewal" under Middle States Accreditation Steering Committee for Vaughn College (Sep 2016 – Apr 2017).
8. Served on committee for revising Vaughn College Faculty Handbook. (Sep 2016 – Apr 2017)
9. Completed improvement modifications to lab equipment and lab exercises for Radar Systems, Laboratory Standard Practices, Integrated Avionics Systems, and Pulse Systems. (Fall 2017)
10. Developed Arduino C programming and sensor integration exercises for Microprocessors course. Purchased a wide array of sensors, actuators and servos and implemented IoT integration and remote sensing using Arduino. (Fall 2017)
11. Attended Seminars:
    - "Certifying Multicore Timing Analysis for DO-178 Avionics Projects" by ConsuNova, Feb 6, 2019.
    - "Owner Maintenance" by FAA Safety Team, Jan 24, 2019.
    - "Transforming the In-Vehicle experience with AI" by QualComm, Sep 12, 2018.
    - "Design Challenges for Aerospace and Defense SDR" by Analog Devices, Jun 28, 2018.
    - "The Hidden cost of your isolated system design" by Analog Devices, Jul 26, 2018.
    - "Innovative Isolated RS-485, SPI and LVDS Communications" by Analog Devices, Jan 10, 2018
    - "Optimizing SMIC 40LL and 40ULP Designs for Speed and Energy Efficiency" by Synopsys, Jan 3, 2018

Jonathan Sypeck

1. Participated in VEX Robotics Middle & High School competition as a Judge (January 2018 & February 2019)
2. Attended Smart Manufacturing Seminar on advanced metal additive manufacturing techniques (October 23, 2018)
3. Engaged with students and industry professionals at the annual Vaughn College Industry Connection Seminar series (Fall 2018 & 2019)
4. Assisted students in their Capstone Degree Projects for their presentations at the annual Vaughn College Technology Day conference (Spring 2017 & 2018).
5. Attended Vaughn's 4th Annual Manufacturing Day Conference on October 19, 2018.

6. Updated EGR450 (Aircraft Configuration Design) and CDE488 (Finite Element Analysis with CATIA) to address competencies related to professional and ethical responsibility including a respect for diversity as well as quality and continuous improvement.
7. Attended Open House for undergraduate students at Vaughn College during spring and fall 2018, and presented engineering and engineering technology program offerings.
8. 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.
9. 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.

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 with the intention to instill in students an awareness of the importance of lifelong learning in meeting their future professional challenges.

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

Richard B Brown
CH-53K/E Aftermarket Chief Engineer
Lockheed Martin
Sikorsky Aircraft - RMS
O: 203-386-7990 M: 475-298-5423

Richard B. Brown is an experienced senior engineering manager with a demonstrated history of working in the aviation and aerospace industry. He is skilled in operations management, management, continuous improvement, engineering and business process improvement and has a focused strength in sustainment engineering leadership.

Brown came to the US in his early twenties from the West Indies where he was a successful high school teacher focusing on the industrial arts, teaching metallurgy and engineering drawing. When he came to the United States, he settled in Long Island New York; it was then he decided to go back to college to pursue his love of aviation, which landed him at Vaughn College, known then as the College of Aeronautics, for further study. He received his bachelor of technology in aerospace maintenance and Bachelor of Science in aerospace and astronautical engineering in 1994.

He knew that at this point in his life he wanted to focus on something he was passionate about such as aviation. Vaughn was well suited to Brown's interest, and in small, hands-on classes in aviation, he was able to work on airplanes and to understand the inner workings of a jet engine and the concepts behind supporting a fleet of airplanes. The ability to combine what he was learning in class with a practical hands-on approach was just the beginning of a successful future in aerospace engineering. "Vaughn laid a great foundation and was very solid at making me a good performer at my first job at Pratt & Whitney. I loved what I studied at Vaughn, and it was very beneficial for me to use what I learned at Pratt."

When thinking about his career options, one of his professors encouraged him to attend an interview session onsite with a representative from Pratt & Whitney. At that time the company was only interested in highly trained powerplant technicians, not engineers. "As I sat in the interview, I realized that I was overqualified at that time. But I still wanted the opportunity to get my hands on engines. I conveyed how much of an asset I would be if I started my second career

working as a tech and then transitioning to engineering." Approximately two weeks later I was called for a second interview and hired as a technician, even though I had a bachelor's degree.

Brown spent two years in that area and was then was promoted into operations, supervising the staff he worked with on experimental engine development. From there his career advanced with roles of increasing responsibility until he eventually became the off-site Engineering and Operations Manager for Pratt & Whitney at Edwards Air Force Base in California where he spent seven years supporting the F-22 and F-35 fighter jets. While in California, he obtained his Master of Business Administration from Capella University.
His next move was to Sikorsky Aircraft in 2013 where he held many roles including general manager and senior manager for Aftermarket Engineering and his current role as the Chief Engineer of Sustainment for the CH-53E Super Stallion and the CH-53K King Stallion heavy lift helicopters.

When asked about the future of aerospace, Brown said "It's all composites and additive manufacturing. Composites are the way of the future. The design and production of components such as blades and airframe panels will be 100 percent composites." Vaughn College certainly agrees, having recently added an engineering certificate in composite manufacturing.

While Brown lost connections with Vaughn for a few years, he came back while working at Sikorsky, a Lockheed Martin Company, and recruited students at the College's career fairs. "I must have recruited a dozen folks from Vaughn. I believe it's important to help students of diverse backgrounds with their career growth to become successful professionals." Vaughn's mission correlates with that sentiment—serving a highly diverse group of first-generation Americans and first-generation college students to become the leaders of tomorrow.

Brown's goals include staying connected to Vaughn College and giving back to future generations of students just as he received support along his own journey. He's been back to make presentations during Black History Month and at the engineering and technology department's manufacturing day and technology day events. Bringing current industry experience in project management and aviation to the students and sharing lessons is very important to Brown. This spring he began teaching an advanced course in engineering project management at Vaughn.

When asked about the future he noted that he would like to see more internship opportunities made available for Vaughn students at Sikorsky. He will work with the engineering and technology department to continue to expose students to internship and career opportunities and continue to encourage a diverse group of student candidates to apply for internships.

Brown is currently the CH-53 Chief Engineer for Sustainment at Sikorsky where he works with many other Vaughn alumni and lives in Sheldon, Connecticut. When not travelling for work, Brown's hobbies include automobiles—he's a self-taught auto mechanic as well as a pilot in training—and enjoys construction and home projects. According to Brown, "I started learning to fly years ago and vow to finish getting my license, then buy a plane kit and build one myself one day."

Jefferson Maldonado, Class of 2016
Senior Robotics Systems Engineer
ArcBest Technologies (ArcBest)
Bachelor's Degree in Mechatronics Engineering, 2016

Growing up in the Dominican Republic, I used to take everything apart and unveil the inner workings of anything and everything that surrounded me. To my childhood self, a circuit board was something magical, I would ask myself "How can this object control the TV channels?" I would often spend countless hours building random structures such as one time putting together a small water filtration concoction out of straws and foam cups.

The move to NYC was life changing. I had to rapidly adjust to a new lifestyle and language. Fortunately, I found my high school's FIRST robotics team. No matter what was happening around me I could always count on my love for taking things a part and putting them back together. This early introduction to engineering was eye-opening, but unfortunately, I did not have the money or the grades to go to a four-year college.
After graduating high school, I joined the U.S. Navy. I was an Aviation Boatswains Mate Equipment (ABE). In other words, I got to work on the catapults and arresting gear of aircraft carriers. My love for taking things apart and putting them back together was of upmost benefit in this job, as we had to do daily preventative and corrective maintenance on multimillion-dollar equipment. I made it to the rank of E-5 and became a work center supervisor, planning and coordinating over 7,600 maintenance actions and maintaining equipment availability to 98%. We would often have engineers visit the ship and work on our systems. I would always reminisce on the times when I was participating in competitive robotics, because I missed the engineering aspect.

I qualified for the GI Bill, a tuition assistance program for service members and decided to leave the Navy to pursue Vaughn College's new Mechatronics degree which combined a mixture of mechanics, electrical components and software. The best part of being at the college was the Vaughn Robotics team. At the time it was a small team, but I couldn't wait until I could get back into building competitive robots again. The Mechatronics program lived up to my expectations; I learned so many engineering concepts that I get to apply daily. The ability to design, build and program competitive robots for four years has given me the expertise to work directly in this highly demanding and competitive field.

At ArcBest Technologies, we create disruptive solutions for the logistics industry. I started as a Robotics Engineer and have quickly progressed to a senior role. In this role, I lead various engineering projects and was nominated for and completed a 10-month corporate leadership program. I thus have the opportunity to work with many engineers of various disciplines, as well as with new sensors and technologies. I'm very grateful to have the opportunity to put all the areas of my mechatronics degree to good use in this career, as robotics heavily relies on the marriage of various disciplines in order to achieve its purpose. I can attribute my success to curiosity, discipline and knowledge. My childhood gave me the curiosity to explore new things without being frightened by their complexity; the U.S. Navy gave me the discipline to exercise structure and consistency, and finally Vaughn College gave me the knowledge to tackle complex problems. After all, "An investment in knowledge pays the best interest." – Benjamin Franklin

Leonie Barden, Class of 2007
Systems Engineer
The Boeing Company
AAS Aeronautical Engineering Technology, 1996
BS Mechanical Engineering Technology, 2007

As a child I have always been fascinated with airplanes. When asked, I used to say that I wanted to be an airline stewardess. Raised by my single mom who is a nurse, she encouraged me to reach for my highest goals. Coming from a family of scientists, most in the medical field, I had little guidance to navigate my path in aviation. I attended an all-girl catholic high school, where my math teacher recognized my abilities and helped to steer me in the direction of trigonometry rather than accounting. This choice became a turning point for me.

After high school, I attended a few different universities (Adelphi and CUNY BMCC) before learning about Vaughn College of Aeronautics. I met with the guidance counselor and career officer at Vaughn who helped me to identify a path to pursue my passion for aviation and to develop my talents. He gave me some career tests which revealed my strengths and suggested that I enroll in the Aeronautical Engineering program until the BS Mechanical Engineering Technology program was ABET approved. I took his advice and completed the AAS Aeronautical Engineering Technology program in 1996. However, the BS Mechanical Engineering Technology program was not approved at that time. The College hired me as a full time PC Tech Trainee, which gave me the opportunity to develop additional skills that I used to pursue a full time career while awaiting the ABET accreditation. Once the BS Mechanical Engineering Technology was approved, I returned to Vaughn College as a part-time student at night.

Working full time and studying part time was a challenge; however, I was determined to pursue my goal. Making the President's List for the honor roll a couple of times gave me confidence that I could realize my goals. Dr. Rahemi, Dr. Kizner and Prof. Mouaouya, to name a few, taught me not only the principles of engineering, but also how to navigate my path when I was felt lost. The technical skills learned during the coursework for my degree provided me the tools needed to receive an offer to work for The Boeing Company as a Systems Engineer upon graduation.

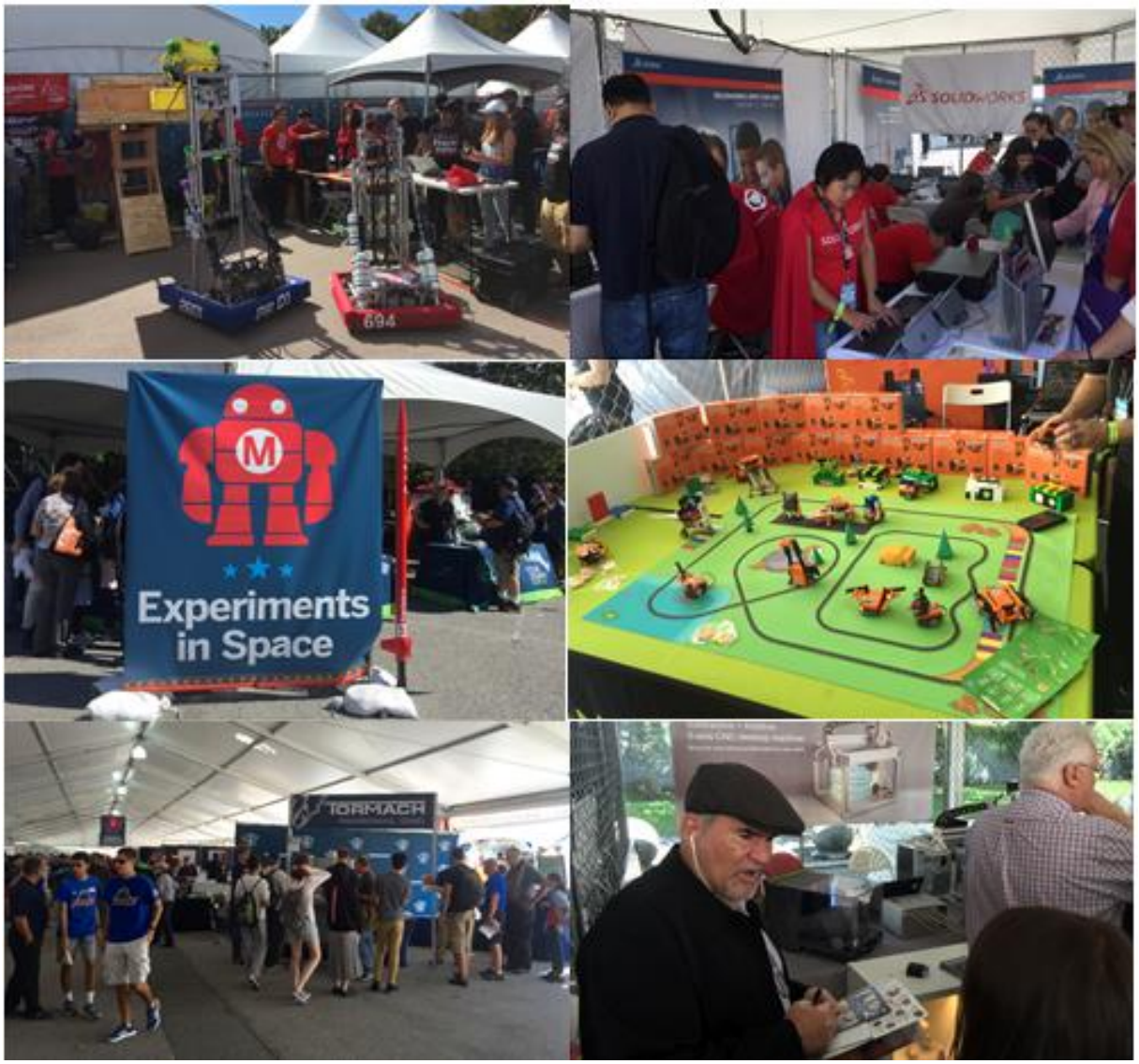
As a Systems Engineer, I have supported various NASA programs including the International Space Station (ISS) and the Commercial Crew Transportation Program (CCTP). I have worked on products from inception to completion (including design, manufacturing, modifications, repairs, and retirement) of hardware used to sustain the ISS. I have performed analysis to support and develop Orbital Tube Welding of fluid systems that will be used on the Boeing CST-100 Starliner, Americas' next generation of spacecraft which will transport American Astronauts to low earth orbit. I couldn't do this work without the education and support received at Vaughn and from my family.

My advice to all students interested in Engineering is to follow your passion. Surround yourself with like-minded individuals to stay motivated. Work hard, study harder, remain vigilant and determined. Believe in yourself and your dreams. To be successful, you must be competitive. Know that at Vaughn you will gain all the skills needed to succeed.

Industry Tour

1. Engineering department Field trip to Maker Faire, Queens, NY

On September 22, 2018, Drs. Hossein Rahemi, Margaret Ducharme, Shouling He, Sundari Ramabhotla, and Prof. Manuel Jesus along with 25 Vaughn's students from engineering programs, UAV, SWE, EWB, NSBE, Robotics, and SHPE clubs traveled to the New York Hall of Science in Queens to attend 9th annual world Maker Faire. This annual event is promoting invention, creativity and engineering. Maker Fair event is a showcase for entrepreneurship and start-up businesses connected to hand-craftsmanship. This event also functions as an interactive gathering of tech enthusiasts, educators, hobbyists, engineers, authors, artists, students, and commercial exhibitors. These "makers" gather at the fair to show what they have made and to share what they have learned. The fair featured six stages and six attraction areas with many presentations and shows.



SWE STEM Workshop at World Maker Fair: This year, Vaughn's Society of Women Engineers chapter had a booth at World Maker Faire and they hosted a STEM workshop which taught participants how a circuit and a motor works and then allowed them to create their own toy car to take home. Vaughn's SWE members encouraged and engaged several groups of children through the building process, and they all were very excited with what they were able to create. This was a huge success for Vaughn's SWE team.

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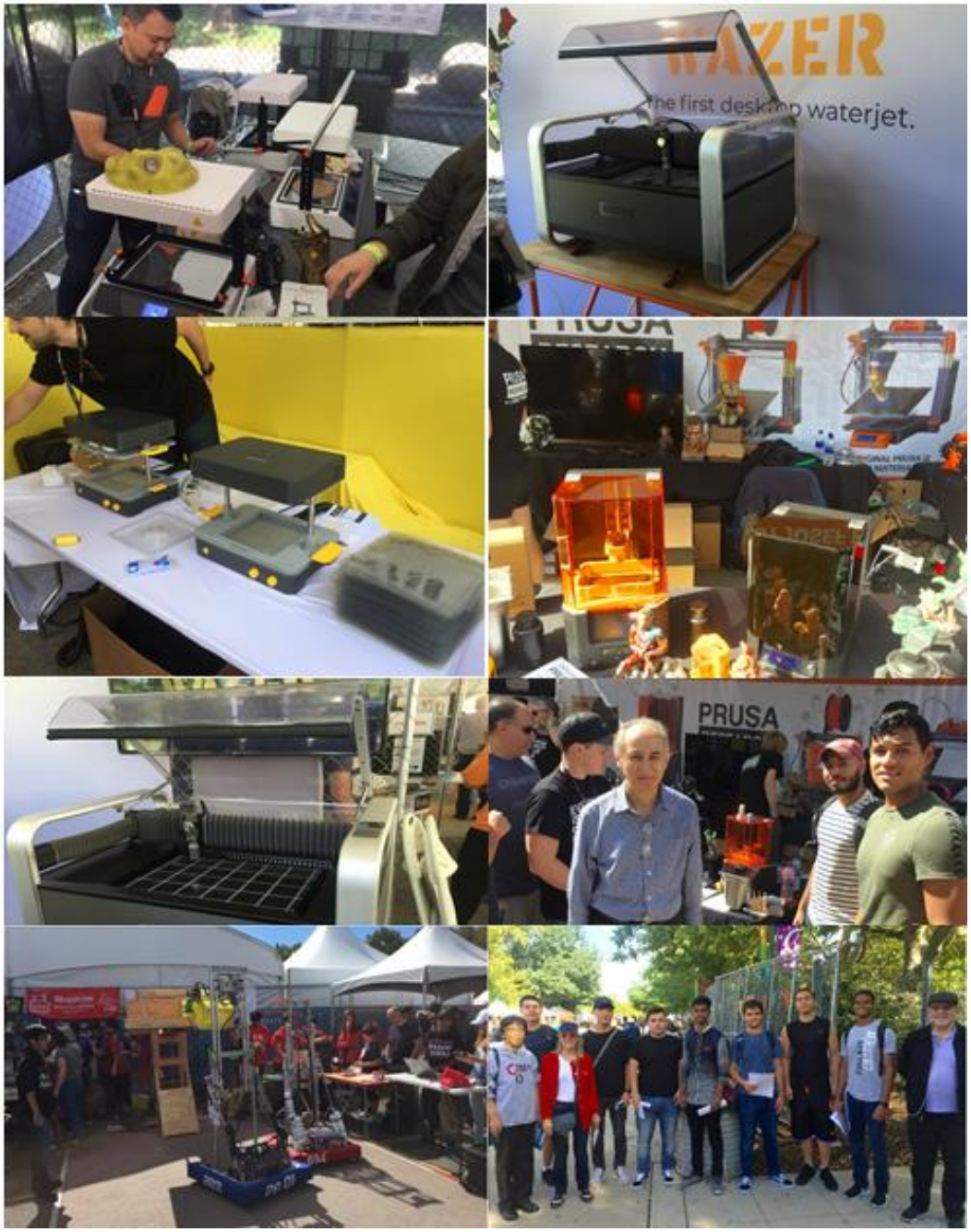
In this trip, Vaughn's student and faculty visited a large number of CNC, additive manufacturing, and desktop vacuum former stands, including those of popular vendors such as FormLab 3D printer, PRUSA 3D printer, WAZER desktop waterjet cutter, 5AXISMAKER CNC (subtractive + additive 5-axis desktop machine), and MAYKU desktop vacuum former. The group also visited the Space Station Explorer stand and robotics show demonstration by robotics exhibiters.



The field trip to the annual maker fair exhibition was a great opportunity for our students to learn about current technology and advancement in the field of engineering, robotics, CNC, 3D printing, and manufacturing,.

2. Vaughn Learning Community Field Trip to 2018 World Maker Fair

The Vaughn Learning Community cohort of engineering students met on Sept. 22, 2018 at the NY Hall of Science in Flushing Meadows, queens, NY for the 2018 World Maker Faire. The archaic spelling of the word "faire" is used to call to mind the outdoor gatherings from the Renaissance period, in which the public celebrates the spirit of science through observation of the most recent inventions created by industry leaders and independent developers.

This field trip was organized within the engineering graphics, robotics design, and writing composition cluster of the learning community. The idea behind the organization of this activity was for students to acquire greater interest in their topics of study and to enhance their classroom learning as they encounter and explore new science exhibits as a shared experience. The students were given instructions to observe and select one technological advance which they would use in the building of their robots. They are assigned an essay on this topic for their writing composition class.

Vaughn Engineering Learning Community students with Prof Ducharme at Makers Faire 2018

3. Field Trip to Google in New York City, October 12, 2018

Friday, October 12, 2018, Vaughn College's Society of Women Engineers arranged for 20 students and 1 faculty member to tour Google in New York City. Upon arrival, students were given a brief tour of the facility with some history of the building. Following this, the students attended a panel discussion with female computer science engineers from different teams. They talked about their daily routines as well as their likes and dislikes in their jobs. The Google team provided Vaughn students with the opportunity and time for Q&A and discussion related to the students' topic of interest.

After the presentation, the students had the chance to learn about the opportunities available at Google for both software and hardware engineers. The guide advised students on how to apply for positions at Google and steps to take in preparation. This tour was a great learning experience for our members and we are grateful for the opportunity to learn more about Google.

Vaughn Engineering Learning Community

Learning communities are formed to foster community among students and to foster connections between students and their instructors. Additionally, students make connections between various disciplines through the integration of co-curricular activities.

Vaughn faculty organized the first iteration of an Engineering Learning Community in the fall 2017 semester entitled D3: Design, Develop, and Deploy. This community was comprised of six courses: MCE 101, ENG 110, FYI 101, CDE 117, PHY 124, and MAT 125. During the fall semester students attended the World Maker Faire at the NY Hall of Science in Flushing Meadows, Queens. This trip was organized within the engineering graphics, robotics design, and writing composition cluster of the learning community. The idea behind this activity was for students to acquire greater interest in their topics of study and to enhance their classroom learning as they encounter new science exhibits as a shared experience. They were given instructions to observe and select one technological advance they would use in the building of their robots and to write a report on how they would incorporate this technology.

In the spring semester this Learning community cohort continued with CSC 316, PHY 225 Lecture and Lab, MAT 225, ENG 120, ELE 117, and CD 101. These students visited the Brookhaven National Laboratory in Upton, NY and had the opportunity to view one of the most advanced synchrotron facilities in the world, The National Synchroton Light source II, as well as the Chilled Water Plant at BNL which provides water conservation techniques. Students thus had the opportunity to gain insight into nuclear and particle physics, photon sciences and nano materials research. Also, since it is part of our mission at Vaughn to *enable students to achieve success in the industries we serve* the students were prepared and encouraged to question the managers at Brookhaven about the specific qualities and skills they look for when seeking new employees.

These students also attended the Intrepid Air and Space museum in Manhattan. The Physics, Math and English professors accompanied the students on this field trip and they had the opportunity to apply the ideas of the physicist Richard Feynman, whom they had read in English class, to the Space Challenger disaster exhibit. On their tour of the USS Growler, these students also had the opportunity to observe how much electronics have developed since the first nuclear-armed submarine in WWII to the advanced GPS systems employed today.

The D3 Engineering Learning community with the same instructors and field trips was employed again with the fall/spring 2018/2019 cohort of students. The experience of these communities culminated in their Signature Project presentation to the college during which the students discussed their reflection posters, showed a film they made documenting the entire process of assembling two drones and flying them, and answered questions, often detailed, posed to them from faculty and administrators.

Report on Vaughn 2018 Common Reading Program

The Arts and Sciences Department at Vaughn College chose Jason Riley's book *Let Them In: The Case for Open Borders* as the common reading selection at the college. This important book takes the six most common arguments against immigration and systematically explains, with supporting evidence, why each of these arguments is unsubstantiated. Jason Riley is a prominent writer on immigration for the Wall Street Journal, in addition to being a member of the WSJ editorial board. He is also a Senior Fellow at the Manhattan Institute.

As part of the Common Reading program at Vaughn, students were assigned Riley's book to read in their ENG 110 English courses. On October 4, 2018 Jason Riley came to Vaughn College and presented his current ideas on immigration, after which he opened the discussion for the 150 students in attendance to ask him questions. The discussion format ran over 60 minutes with students posing questions for which Riley took time to provide thoughtful responses. Afterwards, at least 75 students stood in line to get their books signed by Mr. Riley and to have their photos taken with him. Mr. Riley additionally agreed to have lunch with a group of highly motivated Vaughn students, including the Vaughn Student Government President Wole Bernard.

At the lunch, students enjoyed a further opportunity to ask Mr. Riley questions about the immigration issue and a lively discussion took place throughout lunch.

There will be additional discussion groups, moderated by faculty, held on this subject throughout the month of October, 2018.

Vaughn Students and the Chair of Arts and Sciences with Jason Riley in the Vaughn College tower, Oct 4, 2018

2018 Long Island STEM HUB Career Conversations
Cradle of Aviation Museum, October 24, 2018

On Wednesday October 24, 2018, Vaughn College faculty, students, and staff attended the Long Island STEM HUB careers Conversations at the Cradle of Aviation Museum in Garden City. Attendance was high, and the event was full of enthusiastic participants. Many industries and colleges from Long Island and NY City gathered to inform middle and high school students about STEM educational and career opportunities. Vaughn's engineering and technology department chair along with faculty members Dr. Amir Elzawawy, Prof. Manuel Jesus, and students from robotics and UAV interacted with students and provided them with insight into Vaughn's STEM programs and professional career opportunities.

2018 Long Island STEM HUB Career Conversations

All participants were impressed with the scope of Vaughn College Engineering Department program offerings, student involvement in after class hands-on club activities, technical competitions, and conference participation and presentation. Our students were very excited to talk to prospective students about their own educational and professional experiences at Vaughn College and to share their accomplishment and success stories with them. Vaughn's faculty and staff explained how our small class sizes and one on one student/faculty relationships address students' needs. This was a optimal opportunity for us to learn about other STEM's institutions and industries in the Long island and New York City area.

BMCC STEM Workshop
Borough of Manhattan Community College, October 24, 2018

On Oct 24, 2018, Prof. Mudassar Minhas, Program Coordinator for the Electronic Engineering Technology programs accompanied by Lisa Limbach, Assistant Director of Admissions visited the Borough of Manhattan Community College – CUNY for an open discussion session with prospective students. These students included those nearing completion of their associate degrees in engineering sciences and were invited by Ms. Gehad Gad, Academic Advisor at BMCC.

Prof. Minhas outlined the different programs in engineering and engineering technology at Vaughn College that students could choose from after completing their associate's degrees. Additionally, he highlighted the articulation agreement between the two colleges that enabled the students from BMCC to transfer to certain bachelor's degree programs at Vaughn College with relative simplicity. Prof. Minhas emphasized the quality of Vaughn's engineering and engineering technology programs owing to curricula that serve the needs of the industry, labs that enable students to acquire hands-on and analytical skills, sustained guidance and support through means such as the tutoring center, the writing center and supplemental instructors; and student engagement opportunities through club activities, UAV and robotics competition, and conference participation. The session concluded with a brief Q&A with Prof. Minhas and Lisa Limbach.

Vaughn's STEM Workshop for Hillcrest High School Visit

On Friday November 16, Engineering and Technology department hosted a day of STEM workshop for 27 Hillcrest high school students and their mentors at Vaughn College. The day started at 10:30 am with a visit to Vaughn's state-of-the-art engineering laboratory facilities related to automation, power electronics and smart grids, CNC manufacturing center, mechanical testing, and thermos-fluid lab. Later on students visited both UAV and Robotics rooms where Vaughn's students talked about their activities, accomplishments, and preparation for 2018-2019 robotics and UAV competitions.

In the afternoon Vaughn's UAV and Robotics clubs organized couple of STEM workshops on building a drone, robotics design, and autonomous programming. The UAV club workshop consisted of mechanical, electrical, and programming parts to simulate bi-directional control of a small dc motor. Students also learned the basic principles of C++ programming with the Arduino IDE, and the robotics club conducted a workshop related to robotic design using SolidWorks. The club also instructed students in the structural design process necessary for the creation of a robot that will perform quickly and accurately during a competition.

Overall, students had the opportunity to learn about Vaughn's engineering and engineering technology program offerings and student involvement in professional and scholarly activities. Dr. Rahemi and Mr. Aghassi, director of Career and Technical education, talked about the possibility of establishing a program articulation between two institutions, which will include a possible college course taught at Vaughn for senior Hillcrest students. Another meeting will be organized by Vaughn's STEM pathway Liaison and the Learning Coordinator of Hillcrest High School to explore such articulation. .

PCCC STEM Workshop
Passaic County Community College, Feb 08, 2019

On Feb 08, 2019, Prof. Mudassar Minhas, Program Coordinator for the Electronic Engineering Technology programs was invited to Passaic County Community College for an open discussion session with prospective students on STEM day hosted by Mr. Dennis Reer, Director STEM pathways initiative. Prof. Minhas outlined the different programs in engineering and engineering technology at Vaughn College that students could choose from after completing their associate degrees. Additionally, he highlighted the articulation agreement between the two colleges that enabled the students from PCCC to transfer to bachelor's degree programs in EET – Avionics at Vaughn College with relative simplicity.

Prof. Minhas emphasized the quality of Vaughn's engineering and engineering technology programs owing to curricula that serve the needs of the industry, labs that enable students to acquire hands-on and analytical skills, sustained guidance and support through means such as the tutoring center, the writing center and supplemental instructors; and student engagement opportunities through club activities, UAV and robotics competition, and conference participation. Overall the enthusiasm among students was high and the session concluded with an extensive Q&A with Prof. Minhas.

Industry Connection Seminar

Thursday, September 20, 2018
11 am – 12 pm
Room W155 A & B

Topic: My Dream Job

Presenter: Ms. Leonie Barden, Systems Engineers at Boeing

Ms. Leonie Barden, a 2007 Vaughn College graduate and a systems engineer for the Boeing Company at the Kennedy Space Center, addressed the Vaughn community on Thursday, September 20 as part of the College's Industry Connection Seminar series. Ms. Barden's technical career began with Boeing after completing her BS MET degree at Vaughn. She started as a manufacture engineer and was later promoted to a systems engineer.

In this seminar, Ms. Barden talked about some of her post-graduate and professional experiences. She discussed some of the manufacturing and design projects she was involved with while working at Boeing and told us "Working as a systems engineer at Boeing was a dream job. As a systems engineer, I was involved through design, manufacturing, maintaining process of a project that has taught me so much".

She detailed how her Vaughn College education helped set her on her career path as an engineer and she encouraged Vaughn students to be proactive in their education as well as involved in a student chapter of professional societies.

Barden has more than 10 years of experience in manufacturing hardware for NASA's space exploration programs – International Space Station (ISS) and Commercial Crew Transportation System. Her expertise includes fabrication, modification, assembly and testing of payloads involving thermal insulated soft goods for the ISS.

Her presentation was followed with a 15 minute open discussion session.

Industry Connection Seminar

Friday, November 2, 2018
11 a.m. to 12 p.m., Rooms 155A

Presenter: Mr. Carlo Asaro, Aircraft Avionics Systems Engineer with Sikorsky, a Lockheed Martin Company
Topic: Electronics Design for Aerospace

Mr. Carlo Asaro, an Aircraft Avionics Systems Engineer, addressed the Vaughn community on November 2 as part of the College's Industry Connection Seminar series. Mr. Asaro, has more than 30 years of experience in the industry in research and development, testing and evaluation of rotor-wing electronics with primary focus on power electronics and weapon systems. In this seminar he talked about various Electronics Design and Qualifications of aircraft.

His presentation covered a few of the most important qualifications required for avionics system design in the aerospace industry. He explored the military standards for an avionic power system as well as requirements and testing vital for the installation of new avionics in an aircraft or space vehicle. Moreover, he lectured about his personal experience as an Electrical engineer in the industrial world. He emphasized to the students and faculty that working as an engineer is like passing a final project course. Young engineers need to be ready to face a pressure-filled environment during their careers.

At the conclusion of the presentation, the discussion was opened up for questions from students and faculty.

Industry Connection Seminar

Tuesday, December 4, 2018
11 a.m. to 12 p.m., Rooms E101, 103

Presenter: Mr. Matthew Pearce, NASA Education Programs Specialist
Topic: An Overview of the NASA, STEM Workforce Challenges, and NASA's Internship Programs

Mr. Matthew Pearce, National Aeronautics and Space Administration (NASA) education programs specialist at the Goddard Institute for Space Studies, addressed the Vaughn community on December 4 as part of the College's Industry Connection Seminar series. Mr. Pearce's presentation gave an overview of the NASA, STEM Workforce Challenges, and NASA's Internship and Fellowship programs.

"Bring some deep thought to your future and apply that to your career decision and it will propel you forward," Pearce advised students. "Our motto is 'reach new heights, reveal the unknown and benefit all humankind.'"

Mr. Pearce spoke on current internship options for students, work in the NASA climate change research initiative (CCRI), and its yearlong interdisciplinary vertical STEM education research. Mr. Pearce also talked about the NASA Student Airborne Research Program (SARP) 2019 and encouraged Vaughn's highly motivated students to apply for participation in the NASA Student Airborne Research Program (SARP 2019). Students will work in multi-disciplinary teams to study surface, atmospheric, and oceanographic processes. Participants will fly onboard the NASA DC-8 and assist in the operation of instruments to sample and measure atmospheric gases and to image land and water surfaces in multiple spectral bands.

Students filled room E101/E103 to ask questions and to learn about NASA's fellowship and scholarship opportunities. He encouraged Vaughn's engineering and engineering technology students to apply for those opportunities to gain NASA's valuable career-building experiences.

Mr. Pearce's presentation was followed by 30 minutes of open discussion with students, as well as a visit to the UAV and Robotics rooms; he was very happy to learn about Vaughn students' active involvement, accomplishments, and success in the STEM fields.

Engineering Seminar Series

Friday, December 7, 2018
2 p.m. to 3 p.m., Rooms E101, 103

Presenter: Mohammad Fahim Shahriar, MET Senior Student
Topic: Engineering in Energy Services - A Summer Internship Project at Con Edison of NYC

In this seminar Mohammad Fahim Shahriar, a student in the Mechanical Engineering Technology program who participated in a ten-week summer internship program with Con Edison, addressed the Vaughn community about his summer internship project and life-long learning experiences that he gained through this project.

Mohammad Shahriar, a senior in the Mechanical Engineering Technology program, was assigned to the task of providing a better configuration design for the existing reverse osmosis treatment in Con Edison facility at East River. This examination was conducted with an on field case study that inspired CAD designs to be approved and implemented by concerned departments at the company. All updates to the manufacturing process must be statistically proven before implementation, in order to avoid any risk of defective hardware or a pause in production that could affect output.

His presentation followed with 20 minutes of open discussion.

Engineering Seminar Series

Thursday, December 13, 2018
11 a.m. to 12 p.m., Rooms E103

Presenter: Darwing Espinal, MET Senior Student
Topic: Gulfstream Aerospace Summer Internship Program

In this seminar Darwing Espinal, a student in Mechanical Engineering Technology program who participated in a ten-week summer internship program with Gulfstream, addressed the Vaughn community about his summer internship project and his learning experiences in this project.

Darwing Espinal, a senior in Mechanical Engineering Technology program, talked about his assigned task with the Gulfstream Fuselage Structures Design team for the Advanced Aircraft Programs which is responsible for the design and development of their latest and greatest G500 and G600 Aircrafts. He discussed his involvement in the design process of aircraft fuselage using CATIA software and provided a detail of his team's innovative design to protect the airplane nose form a bird strike.

His presentation followed with 20 minutes of open discussion.

Industry Connection Seminar
Tuesday, April 2, 2019
12 pm – 1 pm
Room W155A

THALES
Together • Safer • Everywhere

Topic: Electric Powered Helicopter
Presenter: Mr. Laurent Ducruet, Director of Business Development

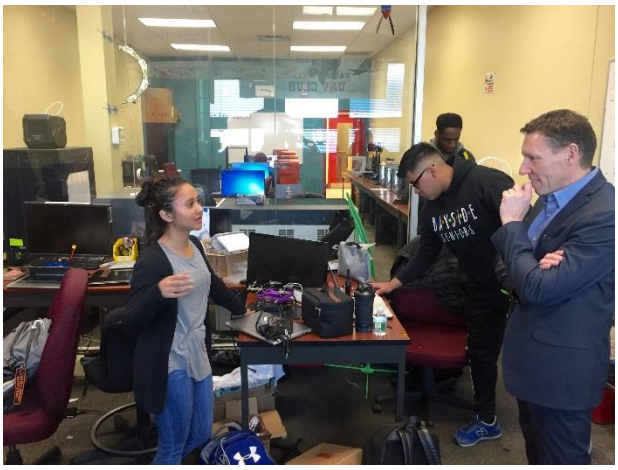
On April 2nd, Mr. Laurent Ducruet, Director of Business Development at Thales delivered a seminar on future trends in drone taxi service, specifically passenger transportation via an autonomous UAV. Mr. Ducruet pointed out that "The next few stages of legal obstacles will be interesting, as manufacturers seek to put autonomous drones into the air."

He mentioned that the systems to operate autonomous vehicles at this level of commercial application are vastly different than the systems for our hobby drones. The basics of most modern hobby drone obstacle avoidance and self-navigation are up to the task, but the bigger picture must be considered.

Factors for successful implementation include the quality and reliability of sensors, drone certification by regulatory authorities, system safety and cybersecurity, customer acceptance, and successful fielding.

Mr. Ducruet highlighted systems being developed and fielded by major players in the market such as Thales, Boeing, Karem, EHANG, VOLOCOPTER, Airbus Vahana, and Bell Helicopters, as well as others. "We will begin to see commercial passenger transport operations as soon as 2025", said Ducruet.

Mr. Ducruet's presentation concluded with an extensive Q&A and open discussion with students, as well as a visit to the UAV room; he was very impressed to learn about Vaughn students' active involvement in drone design and autonomous programming. Sagufta Kapadia, a junior student in the Mechatronic Engineering program, talked about her team's accomplishments and success at the 2018 Vertical Flight Society (VFS) of Micro Air Vehicle Student challenge competition and their preparation for the 2019 competition.



Vaughn's 4th Annual Manufacturing Day, Oct 19th 2018, 10 am to 2 pm

The Engineering and Technology department hosted its 4th Annual Manufacturing Day conference on Friday October 19th 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 additive manufacturing, composite, 3D printing, CNC machining and manufacturing process.

Mr. Richard B Brown, the Chief Engineer at Lockheed Martin (Sikorsky Aircraft), talked about his educational background and how Vaughn's degree prepared him to advance up the career ladder from a junior to a chief engineer at Sikorsky, a Lockheed Martin company. He emphasized education; research, learning, and dedication as keys to success. He also talked about the future of the aerospace industry and how advancement in composite and additive manufacturing is revolutionizing the aviation industry. He mentioned that today's aviation industry has a high demand for graduates with knowledge and hands-on skills in this growing field. At the end of Mr. Brown presentation, Dr Rahemi thanked him for his excellent presentation and added that as one of our alumni, we are very proud of his accomplishments. Dr. Rahemi went on to point out that our certificate program in composite design and manufacturing will provide students with knowledge and skills to support this fast-growing segment of the industry.

The second presenter, Ms. Sari Alyson Gerb, the Academic Ambassador of Dassault Systèmes, talked about her NASA's project "**Designing the Heat Tiles for the Space Shuttle."** Her presentation covered her involvement in the design, development, testing, and manufacturing process of heat resistant tiles for space shuttle Columbia. She mentioned the space shuttle is covered with more than 36,000 heat tiles to protect the space shuttle and its belly from high temperatures (more than 2800 ^{o}F) the orbiter encounters in space and during re-entry. At the end of Ms. Gerb presentation, Dr. Rahemi thanked her for her contribution to the advancement of space science and technology.

The third presenter, Mr. Marvin Blackman, a leading on-site Services Specialist for General Electric (GE), discussed Big Data and its impact on the manufacturing industry. His presentation was delivered in a manner to engage the audience while educating them on several fundamental concepts of Big Data Analytics. Some of these concepts included the Big Data Stack, Artificial Neural Networks (ANN), Predictive Analysis and Hadoop centered technologies. Big Data Use cases were reviewed and discussed to present facts highlighting the importance of Big Data Analytics. Mr. Blackman concluded by emphaszing the fact that the range of Big Data uses in the manufacturing industry is limited only by available data and imagination.

Morning Session of Manufacturing Day Conference – Presentation of Industry Leaders

In the afternoon session, Dr. Rahemi updated audiences with the news that two certificate programs in Additive & Subtractive Manufacturing, and composite manufacturing have been approved by the NYSED. Prof. Manuel Jesus, CNC and 3D curriculum designer, talked about the development process of CNC machining and manufacturing certificate program. Prof. Jesus' presentation covered laboratory development related to software, hardware, 3D scanning, CNC lathe and other equipment that can support implementation of both additive manufacturing and CNC machining certificate programs. Also, his presentation addressed the development process of five courses as part of the new CNC machining and manufacturing certificate program. After review by the manufacturing curriculum committee, a proposal of this certificate program will be submitted to the NYSED for their approval. Dr. Budhoo, composite curriculum designer, talked about the development of laboratory equipment that provides students with the hands-on skills current with today's technology in the composite manufacturing industry. His presentation covered nondestructive laboratory equipment that can be used to detect flaws and imperfections in composite structures.

Faculty presentation to invited guests and Vaughn community

Finally, Vaughn's UAV club provided a presentation about their success story in the 2018 Micro Air Vehicle student challenge competition of the American Helicopter Society (AHS) Conference. They talked about the design, development, and construction process of their manual and autonomous drones that satisfy AHS size and weight requirements as well as perform the best vertical takeoff & landing (VTOL) with onboard flight-stabilization and camera. As the 2018 winners of the Micro Air Vehicle competition, Vaughn's remote control team received "Best Remotely-Controlled Target Search" award (first place award) and a $2000 check. Vaughn's autonomous team was the only team that for the past three years has been able to accomplish vertical take-off and partially complete the autonomous category, and for this achievement they received the "Honorable Mention" award and a $1000 check.

In conclusion, Dr. Rahemi informed the group that the department is in the process of completing and submitting applications for two more certificate programs in CNC and automation to the NYSED. He emphasized the establishment of those stackable certificate programs with the state-of-the-art laboratories in 3D printing, CNC machining, composite manufacturing, PLC & automation, and the UAS center which will not only provide our engineering and engineering technology students with hands-on manufacturing skills but also produce versatile skilled-graduates who can contribute to advancement of today's manufacturing and aviation industries. Finally, Dr. Rahemi thanked all industry advisory members and guests for their continuous support in every aspect of the department and institution.

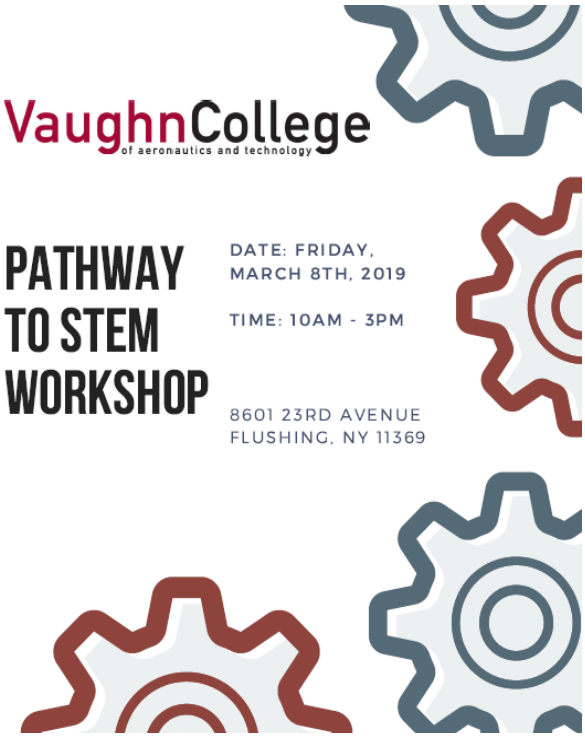
STEM Outreach Workshops

In a parallel session, from 10 am to 2:00 pm, Vaughn's UAV and Robotics clubs organized and hosted STEM workshops on building a drone, robotics design, and autonomous programming for the high school students from Freeport, Bayside, Thomas Edison, ESBOCES Engineering, and West Islip high schools. The UAV club workshop consisted of mechanical, electrical, and programming parts to simulate bi-directional control of a small dc motor. Students learned the basic principles of C++ programming with the Arduino IDE. Additionally, students learned to work with electrical components such as a potentiometer, h-bridge motor controller, diodes etc., and they assembled and programmed the circuits in two sessions. 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 Department of Education federal fund as part of Title III, Part F, HSI-STEM and Articulation grant.

UAV and Robotics Workshops Session

Vaughn's STEM Day Workshop
March 8, 2019, 10 am to 2 PM



The engineering and technology department hosted its first STEM Day workshop for community college students on Friday March 8.

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.
- **3D Printing and Additive Manufacturing Workshop:** Introduction to 3D and surface modeling using Solid Works and CATIA with 3D additive manufacturing processes.
- **Avionics Workshop:** Introduction to avionics with hands-on experiences related to aircraft radar, communication and navigation systems.
- **CNC Workshop:** Introduction to HASS VF-2SS CNC milling and cutting machine and manufacturing processes.
- **Build A Drone Workshop:** Introduction to building and manufacturing processes of flying robots.
- **Robotics Workshop:** Introduction to structural design processes that is necessary for creating reliable and durable robots for robotic competitions.

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.

During the lunch break, Vaughn's junior student, Atif Saeed talked about his experiences and after-class involvement in professional clubs, as well as his conference participation and publications. He emphasized that involvement in both technical competitions (Robotics and UAV) and scholarly activities helped him to get two internship offers from NASA and Lockheed Martin.

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 robotics design and construction. Finally, from 2:00 pm to 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.

Vaughn's International Drone Day, May 5, 2018 10 am to 3 pm

On Saturday May 5, 2018, 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.

These workshops, organized by the engineering and technology department and the Unmanned Aerial Vehicle (UAV) club, 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. Finally, the Python workshop introduced participants to programming and coding with Python.

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 Zion's program, Robert F. Kennedy Community, Thomas Edison, and Bayside high schools. Vaughn's UAV team flew their drone, which had been selected by the American Helicopter Society (AHS) as a finalist for both manual and the autonomous categories for the 2018 AHS Micro Air Vehicle (MAV) competition. This MAV competition will take place on May 14, 2018 in in Phoenix Convention Center. This is a tough and challenging competition in which only the top teams with supporting documentation and videos proving their drones can complete the tasks were invited as finalists to compete in the Annual American Helicopter Society Micro Air Vehicle (MAV) competition. Besides Vaughn's team, two other schools (Penn State and University of Maryland) were also selected as finalists in the AHS-MAV competition. Vaughn's UAV team provided a brief presentation of their drone design, which employed 3D printing parts and autonomous programming, to the participants of Vaughn's International Drone Day. Also, service awards were presented to two graduating UAV members (Daniel Khodos and Luis Goncalves) to celebrate their contribution and accomplishment towards the advancement of Vaughn's UAV team.

Workshops: CAD Modeling of Quadcopters, Build a Drone, Python Programming, and Drone Panel Discussion - Vaughn's International Drone Day, May 5 2018

Vaughn's UAV team participated in the American Helicopter Society Micro Air Vehicle (MAV) competition, May 14, 2018 - Vaughn's UAV team received top awards at the 2018 MAV Competition

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 the Phoenix Convention Center on May 14, 2018. 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 (464 grams remote drone and 499 grams autonomous drone) 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 then would takeoff from the delivery station and land on the pickup station to pick up a 2nd package and 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. Vaughn's remote control team was the only team that completed three flawless successful runs within the 10 minutes permitted time. For the autonomous session, only Vaughn's autonomous team was 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 15, Judges from aerospace industries evaluated teams' performance for both the remote and autonomous control categories. Vaughn's UAV team received the highest score in both categories. As the 2018 winners of the Micro Air Vehicle competition, Vaughn's remote control team received "Best Remotely-Controlled Target Search" award (first place award) with a $2000 check. Vaughn's autonomous team was the only team that for the past three years was able to have vertical take-off and partially complete the autonomous category and for that they received the "Honorable Mention" award with a $1000 check. Ten members of the Vaughn College UAV team (Chamathke Perera, Marc Gonzalez,, Bobby Tang, Atif Saeed, Utsav Shah, Harold Gonzalez, Sagufta Kapadia, Lovedeep Kaur, Syed Misbahuddin, Peter Kalaitzidis) were all a part of the 2018 AHS-MAV student challenge competition.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6th annual American Helicopter Society Micro Air Vehicle (MAV) Student Challenge Competition, May 14, 2018 – Vaughn's UAV team finished 1st and received "Best Remotely-Controlled Target Search" in the remote control category and "Honorable Mention" in the autonomous category.

COE 2018 Annual Experience and Technical Fair

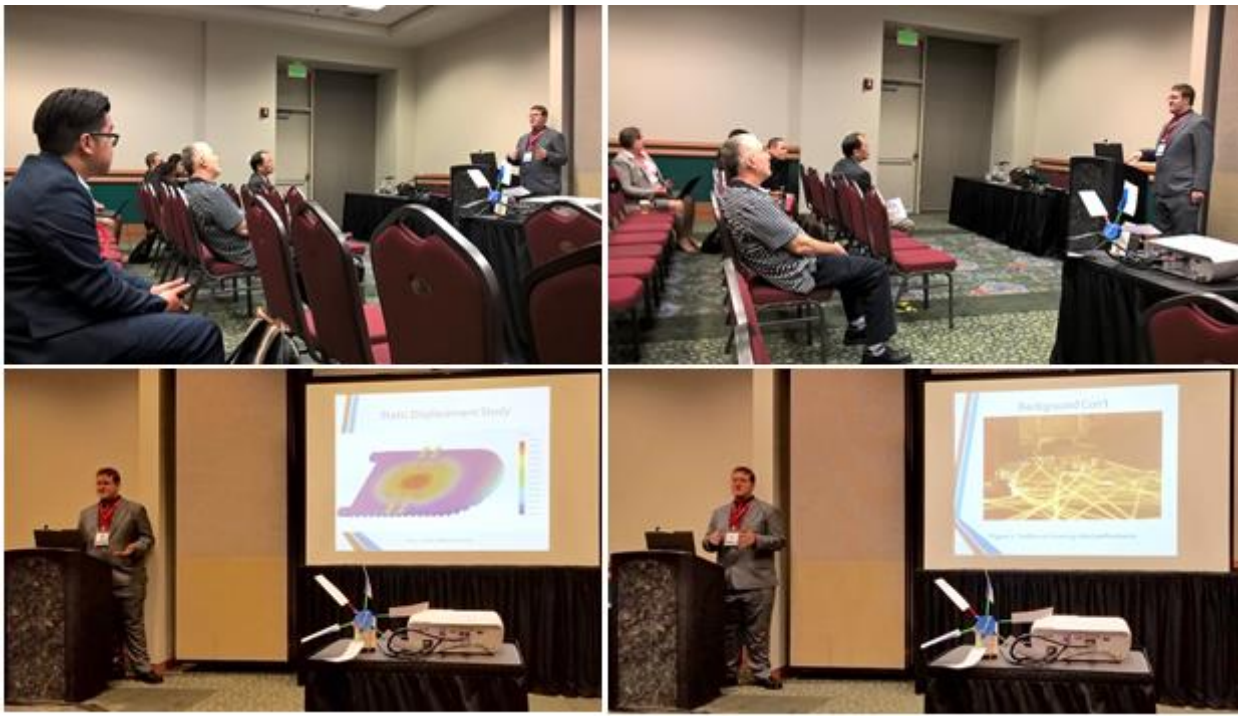
From April 15 to 18, Four of Vaughn's engineering and technology students, along with department faculty, participated in Dassault systems solution 'Community of Experts' Annual Experience and TechniFair which was held in San Diego, California. During the student poster session, Mr. George Chern and Mr. Olawatobi Ayade presented their project "Sterling Engine" which demonstrated the utilization of CATIA in the design, assembly and analysis process. Mr. Jamal Sharifi and Mr. Nicolas Ceballos demonstrated the use of CATIA in the design process of their project, "Foldable Stool". These two groups of students representing Vaughn College received third and fourth places, respectively, in a student competition involving 16 teams.

The COE 2018 Annual Experience and TechniFair is a three day event to bring together expert users of Dassault Systèmes solutions. Students had the opportunity to attend keynote presentations from industry leaders, see the latest product developments, learn solutions to business challenges, connect with experts during networking receptions and visit the TechniFair, featuring more than 30 vendors.

Vaughn's engineering students and faculty presented their research projects at 2018 ASEE Annual Conference and Exposition.

From June 24 through June 27 Vaughn faculty and students attended the American Society for Engineering Education (ASEE) 125th annual conference in Salt Lake City, Utah.

On Monday, June 25, Vaughn student Daniel Khodos presented his team capstone research project "**Team Cleaning Robots**" during the Capstone Projects session. His presentation detailed the development process of an innovative robotic vacuuming system. The system consists of two Omni-drive robots: a Slave Robot (SR) and a Master Robot (MR). The SR works independently. It sweeps dust and dirt from floor surfaces, including the corners of a room, beneath cabinets, and behind tables and other furniture. Additionally, it sends information/data to the MR. The MR computes an efficient path to vacuum dust and dirt in the sections of the room based on the information/mapping transmitted by the SR. Further, the MR identifies garbage bin locations in an office by using Robot Operating System (ROS) and a Movidius Image Processing unit and empties these receptacles. Two autonomous robots in the vacuum system are programmed using ROS under Linux Ubuntu. A LIDAR is installed on each of the robots, and path-planning algorithms allow them to navigate around obstacles. The autonomous teaming robots are mainly designed to clean commercial office areas; however, they may also be used for residential spaces.



On Monday, June 25, Vaughn faculty members Dr. Hossein Rahemi, Engineering and Technology department chair, Dr. Margaret Ducharme, Art and Science department chair, Dr. Amir Elzawawy, Mechanical Engineering program coordinator, and Prof. Khalid Mouaouya participated in the 2018 ASEE annual conference and presented their paper "**Enhancing Student Learning Outcomes through the Freshmen Summer Engineering Experience (SEE-STEM) Program**." during the Student Success session. The paper and their presentation detailed the process for the summer bridge program in preparing students for the core courses within engineering disciplines as well as enhancing students' hands-on, computational, programming, communication, teamwork, and problem solving learning outcomes.

To assess the effectiveness of the SEE program, both a student learning outcomes assessment process based on topics covered in the program and a continuous improvement loop are used. This process includes the following direct and indirect assessment process:

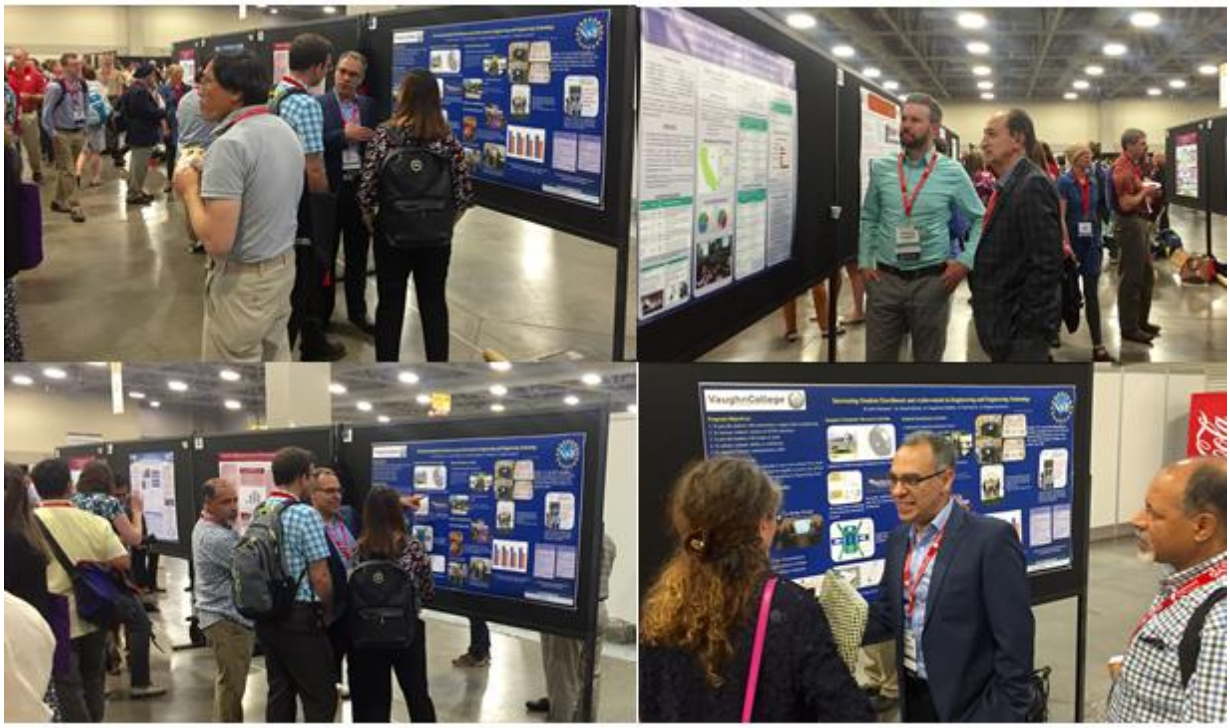
- **Student's Evaluation Survey of the SEE Program**
  As an indirect measure, a rubric survey based on the contents of the SEE program is given to students to assess the effectiveness of this program.
- **Faculty Evaluation Survey**
  As a direct measure, a rubric faculty evaluation survey based on student learning outcomes provides assessment of those outcomes in students' projects and presentations.
- **Monitoring and assessing SEE students' performances in their discipline of study**
  As a direct measure, the performance of two cohorts of students who participated in 2016 and 2017 SEE programs are monitored through core courses within their discipline of study and compared with those students who did not participate in the freshmen year of the Summer Engineering Experience program.

In assessing the summer STEM program, our overall goal is to ensure that at least 70 % of the students achieve a success rate of a score above satisfactory for each outcome, as indicated on the rubric. An outcome with a success rate below 70% requires an action plan for improvement.

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 implement the SEE program.

On Monday (9:45 am -11:15 am), June 25, Vaughn faculty members Dr. Amir Elzawawy and Dr. Hossein Rahemi presented their NSF project "**Increasing Student Enrollment and Achievement in Engineering and Engineering Technology**." during the NSF Grantees Poster Session of ASEE annual conference. Their poster detailed the process for the NSF STEM Scholarship program at Vaughn College of Aeronautics and Technology from 2012-2017. The Project is focused on increasing enrollment and retention of talented students in STEM undergraduate education. The project included two cohorts; each cohort goes through a four-year plan. In the first year, all scholarship recipients are engaged in learning communities with well-defined projects in applied engineering such as robot building, truss design, flow visualization and aerodynamics. These hands-on modules are intended to assist students in making connections between math and physics courses and their engineering applications. In the second year, students (now sophomores) received tutor training and provided tutoring in fundamental courses to their fellow freshmen. This practice is intended to give students the opportunity to establish strong links between related courses (statics and mechanics of materials or thermodynamics and fluid mechanics) in their 1st and 2nd year, and to further enhance their hands-on, critical thinking, teamwork and communication capabilities.

The third and fourth year scholarship recipients were involved in research activities to prepare them for the post-graduation. These activities provided students with a unique opportunity to work with faculty members in group research projects. All program participants have the chance to present their projects in the college's Annual Technology Day Conference in April, and many of these projects are submitted and accepted for presentation and publication in regional, national, and international conferences such as ASEE, ASME, SEM, and LACEEI.



On Tuesday (3:15 pm – 4:45 pm), June 26, Dr. Mohammed Benalla presented his paper entitled "**Student Community Project to Design a Mini-golf for the City of Leesville, LA.**" during the Engineering Technology Division of ASEE annual Conference. His paper described a community project to design a first draft of an 18 hole mini golf course with a future location in the city of Leesville, LA. The course was designed to be challenging and aesthetically pleasing and to incorporate themes reflecting the history and culture of the city in order to promote tourism as well as to create an enjoyable location for local residents. The project was designed by students from the Engineering Technology, ET, and Creative & Performing Arts, and CPA, departments. Groupmates from these departments operated closely under the supervision of two faculties from ET and CPA to produce a design proposal along with graphic illustrations that highlighted various themes related to the historical and cultural aspect of the city. The design started with a hand sketch that was modified to fit the course area; then, an architectural illustration was accomplished using AutoCAD. The theme of the mini golf course illustrated the most important moments in the civil and cultural history of the city: No Man's Land, Railroad, Timber Boom and Fort Polk.

On Wednesday (8:00 am – 9:30 am), June 27, Dr. Shouling He presented her paper titled "**Multi-sensors for Robot Teaching Using Raspberry PI and VEX Robotics Construction Kits**" during the Automation in Manufacturing session of this annual gathering. Her paper presents an engineering design approach to develop an instructional module for college students to learn Microprocessors and Robotics using multiple sensors, microprocessors and software design tools. The activities include showing students how to build teaming robots by combining the Cortex controllers with ROBOTC programming environment under Windows and the Raspberry Pi (in ARM cores) using Python under Linux, and guiding students to develop a cross-platform software and hardware design using PIC Microcontrollers with embedded C under Windows and the Raspberry Pi with Python under Linux.

Vaughn's Engineering Faculty and Students Participated in LACCEI2018 Conference; Vaughn's Students Take Third Place at LACCEI 2018 Poster Competition

From July 17-20, Vaughn's engineering and technology students, along with Dr. Paul LaVergne, academic vice president, and engineering department chair, Dr. Hossein Rahemi attended the LACCEI 2018 Conference in Lima, Peru. Six Vaughn student team research papers were accepted for presentation and publication in the LACCEI 2018 international conference; two Vaughn student papers were selected to compete among ten finalists for the student paper session, and all three submitted papers were accepted for the poster session of LACCEI 2018.

From 11 am to 1 pm on Thursday July 19, two of our student team papers were presented to the international conference audience during the student paper session of LACCEI 2018. The "**Smart Autonomous Robot Design for VEX U Challenge - In The Zone"** by Niki Taheri and Atif Saeed and the "**Development Process of a Smart UAV for Autonomous Target Detection"** by Utsav Shah, Ryan Tang Dan were both finalists in the student paper session of LACCEI 2018.

Niki and Atif talked about their robot project that was designed, developed, and constructed during the fall of 2017 in preparation for the 2018 World Championship. This paper outlines the project idea of creating a robot to compete in matches with a forty-five second autonomous period followed by one minute and fifteen seconds of driver-controlled manipulation. During fall 2017 and spring 2018, they participated in many regional and international competitions and their robot competed successfully and won tournament Championship and Finalist awards as well as automatic qualification to participate in the 2018 VEX U World Championship.

Utsav and Ryan talked about their remote and autonomous drone projects designed, developed and completed during the spring of 2018 in preparation for the American Helicopter Society International 2018 Micro Air Vehicle Student Challenge (May 14, 2018). This paper outlines the project idea of creating two micro aerial vehicles weighing less than 500 grams and sized less than 450 millimeters in any dimension. The quadcopters designed in this project have two different types of package delivery, pickup, obstacle avoidance, and hover/landing capabilities with autonomous and manual control. Their drones won first place in both remote control and autonomous categories of the 2018 American Helicopter Society MAV student challenge.

LACCEI2018 Student Paper Session Competition

LACCEI 2018 Poster Competition

From 2:30 pm to 4:30 pm on Thursday July 19, a total of 45 posters were presented during the poster session of the LACCEI 2018, including three of Vaughn's student team posters; **1) Smart Autonomous Robot Design for VEX U Challenge - In The Zone** by Niki Taheri and Atif Saeed, **2) Development Process of a Smart UAV for Autonomous Target Detection**, by Utsav Shah and Ryan Tang Dan, and **3) Compactable Stool** by Jamal Sharifi and Nicolas Ceballos. Among all participating teams, Vaughn's **Smart Autonomous Robot Design for VEX U Challenge - In the Zone** poster received the third place award for the best poster presentation of this session.

Niki Taheri and Atif Saeed, Vaughn's Mechatronic Engineering students, received the third place award in the student poster competition from executive director of LACCEI, Dr. Maria Petrie.

The 6th Annual IEEE North Jersey Advanced Communications Symposium

The 6th Annual IEEE North Jersey Advanced Communications Symposium was held at the Babbio Center, Stevens Institute of Technology, in Hoboken, NJ on Saturday, September 15, 2018. The advanced topics in artificial intelligence, big data, machine learning, deep learning, and application were covered in the symposium. The poster presentations also demonstrated further more applications in these related areas.

Dr. Shouling He attended the symposium to discuss these topics with the presenters and attendees. One of these remarkable topics is how to incorporate fundamental concepts of machine learning as well as deep learning into undergraduate classes so that students can learn the latest developments in these areas and search out the possibilities of building intelligent robots for industrial manufacturing and automation. The symposium also provided some interesting academic and undergraduate student research results, such as drone video analytics using deep neural networks, cognitive radio signals and deep machine learning.

2018 Society of Hispanic Professional Engineers (SHPE) National Conference, Cleveland, Ohio, November 7-10, 2018

A group of 16 engineering students from Vaughn College attended the 2018 Society of Hispanic Professional Engineers (SHPE) Conference in Cleveland, Ohio from November 7 to November 10, 2018. Vaughn's students participated in 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.

Vaughn's students received 38 interviews with companies such as Cummins, Nissan, BorgWarner, Huntington, UTAS, Pratt & Whitney, Raytheon, Toyota, Honda, Ford, Nissan, John Deere and more.

From Left to right, SHPE National Convention Attendees; Luis Santana, Lennin Luna, Hector Sabillon, Nurullah Khan, Robert Escobar, Nicolas Ceballos, Cesar Valles, Angel Calderon, Yarelys Vazquez-Marquez, Frandi Cueva, Darwing Espinal, Miguel Cordero, Parminder Singh, Abdullah Ali, Jairo Chauca, Kirei Watson, Parneel Kumar

The following is a list of members and the companies with whom they received interviews and/or pending offers. As an outcome of being familiar with recruiters while visiting other SHPE events, Darwing Espinal, Nicolas Ceballos and Kirei Watson were asked to join UTAS for a tour of this facility in December. In an 8% increase from last year, 88% of our members received interviews. At this year's conference, 10 out of 16 students received offers for either intern or full-time positions. The following is a list of Students and the companies with whom they have chosen to work:

Name	Year	Company	Position Accepted
Abdullah Ali	Senior	Cummins	Full-time Offer
Angel Calderon	Sophomore	Nissan	Summer-Intern 2019
Darwing Espinal	Senior	Raytheon	Full-time Offer
Frandi Cueva	Junior	Toyota	Co-op 2019

Hector Sabillon	Senior	John Deere	Full-time Offer
Jairo Chauca	Senior	Harris	Full-time Offer
Kirei Watson	Senior	Collins Aerospace	Full-time Offer
Nicolas Ceballos	Senior	Sikorsky	Full-time Offer
Robert Escobar	Senior	Turner	Full-time Offer
Yarelys Vazquez-Marquez	Junior	Pratt & Whitney	Summer-Intern 2019

Extreme Engineering Challenge (Wednesday and Thursday):

We encouraged all our members to participate in the Extreme Engineering Challenge and everyone successfully entered the competition. Due to the success of this experience, we are interested in hosting a similar event at Vaughn College. When our members participate in competitions or attend conferences, they receive the benefit of enriching their resumes with these experiences.

This year, **Angel Calderon's** design idea "**Adaptive Air Intake** – Enhancing efficiency of existing engines and reducing carbon footprint" was accepted to compete in the 2018 Nissan Design 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. Angel presented his innovative design idea to distribute airflow in opposite directions, heated or cooled, in order to use less fuel in the cylinder, without sacrificing torque.

At the conclusion of the challenge, Vaughn student, Angel Calderon's design idea "Adaptive Air Intake" won **First place** in this challenging competition. This is the second time in a row that a student at Vaughn College has won the Nissan Design Competition. In 2017, Darwing Espinal's design idea "An Active Suspension System" won third place in this competition.

The Vaughn community is very proud of Angel's and Espinal's success in this 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 students in STEM related scholarly and professional activities.

STEM Report – STEM Career Expo at the New York Hall of Science, Queens NY
By Lisa Limbach, STEM Pathways Advisor and Transfer Liaison/Assistant Director of Admissions

The New York Hall of Science in Queens, New York hosted their third annual STEM Career Expo on Friday, May 11, 2018. It is a free event for any individual interested in the fields of science, technology, engineering and mathematics to experience hands on learning activities and network with various STEM professionals. Vaughn College of Aeronautics and Technology had the opportunity to attend and exhibit at the event. I was accompanied by Vaughn College Animation and Digital Technologies Program Coordinator, Professor Manuel Jesus, at the College Exhibition section of the expo. Other universities and colleges including CUNY Hostos Community College, CUNY Hunter College, SUNY Binghamton University, SUNY Maritime College and University of Maryland College Park participated. Alongside the college exhibit were panel speakers and professional organizations and companies.

It was highly attended with well over 500 extremely bright and motivated middle school and high school students and family members asking about the programs and college experiences. Many of the students I spoke with were interested in engineering and technology, specifically film and graphic design and medical technologies and robotics, and they were highly impressed with the specific programs we offer. Since Vaughn College is one out of four colleges in the United States that has mechatronics engineering program accredited by the Engineering Accreditation Commission (EAC) of ABET, students were attracted to this program. Many students were also impressed with the small class size of approximately fourteen students to one instructor.

Although it was a busy event, most of the attendees showed greater interest in the hands-on learning experiences and panel discussions than in the college exhibit. In preparation for next year's STEM Career Expo, a professor or Vaughn College alum should speak on the behalf of the college during the panel discussion and also prepare a hands-on experience for our college exhibit.

Training course at Abaris Training facility Reno, Nevada
Advanced Composite Manufacturing II

On May 14, 2018 Dr. Budhoo attended a five day training in advanced composite manufacturing II in Reno, Nevada. The purpose of this training was to enhance his knowledge and skills in composite manufacturing so he can better develop the composite manufacturing certificate at Vaughn College.

During this training students obtained an understanding of composite layup and vacuum bagging techniques for complex shapes, fabrication of potted honeycomb core assemblies, manufacturing composite component parts using production type tooling, knowledge of machining, trimming and drilling composite components using fixtures, surface preparation methods/secondary bonding of structures, and component assembly methods and techniques. The necessity for documentation and record keeping to support composite manufacturing was also covered.

Some of the key lecture topics covered included:

- Quality assurance in manufacturing; planning, in-process inspection, and record keeping.
- Mold preparation; using semi-permanent polymer release systems.
- Challenges in layup of complex geometries: maintaining ply orientation/symmetry.
- Vacuum bagging complex shapes for oven and autoclave processing.
- Introduction to tooling: component specific molds and fixtures.
- Overview of non-destructive inspection methods.
- Documentation of in-process and post-process operations.
- Resin ingress vacuum egress plumbing design.
- Darcy's law/permeability discussion.
- (RTM), Vacuum Assisted Resin Transfer Molding (VARTM), etc.
- Resin infusion processes: Vacuum Infusion Process (VIP), Resin Transfer Molding
- Composite structure assembly methods and procedures.
- Mechanical fastening methods and techniques.
- Surface preparation and adhesive bonding of composites Vs metals.
- Machining, trimming, and drilling composite components.
- Rejection reports, cause and corrective actions

Some of the key laboratory exercises included:

- Mold preparation: clean, seal, and release molds for service.
- Cut and machine honeycomb core materials for use in layup.
- Cut and kit prepreg fabrics and adhesives for panel build.
- Layup, vacuum bag, and process complex sandwich core panels.
- Demold and inspect parts using non-destructive methods.
- Part marking, packaging, and storage of parts used for assembly.
- Trim and drill components for assembly using Trim and Drill Fixtures (TDF).
- Surface preparation and bond-assembly of components.
- Installation of bonded nutplates and inserts.
- Prepare mold for infusion layup process.
- Layup preforms, arrange inlet and vacuum plumbing, vacuum bag, and infuse panel.
- Inspect all panels and assemblies and document findings.

Atlantic Design and Manufacturing Conference

From June 11-15, 2018 Professor Manuel Jesus attended the Atlantic Design and Manufacturing Conference held in NYC at the Javits Center in Manhattan. The show was a great opportunity to engage with companies that develop all sorts of manufacturing equipment. Prof. Jesus attended the show to explore new developments in 3D metal printing and found some interesting advancements. Although detailed information is available online regarding all the equipment shown, nothing compares with seeing a system firsthand.

The event had a great range of manufacturers ranging from industrial electronics to machine shops. Many of these companies serviced assembly line production, food packaging, medical equipment, and printed circuit board manufacturing. One of his goals was to connect with local firms open to hiring students and recent graduates from our mechatronics and engineering programs. Exhibitors seemed interested in connecting students with opportunities and some follow up will be required. Throughout the show floor I saw some great examples of equipment useful for student activities such as capstone degree projects, the UAV Club, and Robotics club. Vendors had everything from console electrical switches, robot sensors, and LCD displays, to ABS plastic project enclosures. The show planners catered to the maker community by having a ready supply of free samples, detailed catalogs, and follow-up sales information.

The priniciple aim of college attendance at this show was to see the Desktop Metal 3d Printer that Vaughn College is interested in purchasing. The unique aspect of this machine is its ability to operate in an office setting without an expensive exhaust system. Metal print part finish appears similar to a forged metal part, as the prints are post processed in an oven. A metal 3D printer can potentially be a great accessory to our HAAS CNC system as metal stock parts can be 3D printed then refined to a factory finish on a CNC machine. Other 3D printer offerings from 3D Systems used an SLA UV laser based 3d printing method for ultra-high resolution part surface finish and feature size. The most exciting development here is that costs have come down considerably while quality has increased. Lower priced products allow us to redirect grant funding to better serve our students.

Embracing the local maker community and inventors in addition to large scale manufacturing brought a younger crowd to the show. A well rounded approach like this will give our students great networking options when looking to connect with future employers or just trying to source some equipment for a school project.

SME Smart Manufacturing Seminar Series: Metal Additive Manufacturing Developments, Philadelphia, Pennsylvania, October 24, 2018

Professors Douglas Jahnke and Jonathan Sypeck attended the Metal Additive Manufacturing Developments seminar in Philadelphia. The seminar is part of the Smart Manufacturing Seminar Series presented by the SME. The series focuses on advanced manufacturing technologies and tools that are driven or enhanced by integrated information technology.

Sessions included discussions on how to move from using metal additive manufacturing just for prototyping and expand to using it for production, best design practices for 3D metal powder-bed fusion, and a strategic approach to additive manufacturing. A session of particular interest was given by a company with a novel approach to additive manufacturing. Their approach was to use thin layers of metal and bond them ultrasonically. This method does not generate heat or significant pressure and allows the embedding of sensitive items and materials. As with additive manufacturing in general, this process presents new opportunities for the way we think about design.

Quanser Technical Training: Autonomous Vehicles Research Studio (AVRS) and Flight Control Systems

On Tuesday Dec 11, 2018, Dr. Elzawawy conducted a site visit to Quanser Inc in Markham, CA. The visit involved a morning session focused on technical training on Autonomous Vehicles Research Studio (AVRS). In the afternoon, Dr. Elzawawy met with Quanser's sales and system engineers to discuss the UAV laboratory planned at Vaughn College in the 2019/2020 academic year.

In the late afternoon, another training session focused on other UAV flight control equipment such as 2 DOF flight control using PID, 3 DOF Hover, Aero-Gimbal, and QDrone. The Quanser training session provided knowledge to share with our engineering students who need to keep up with these technical skills in such a fast growing field.

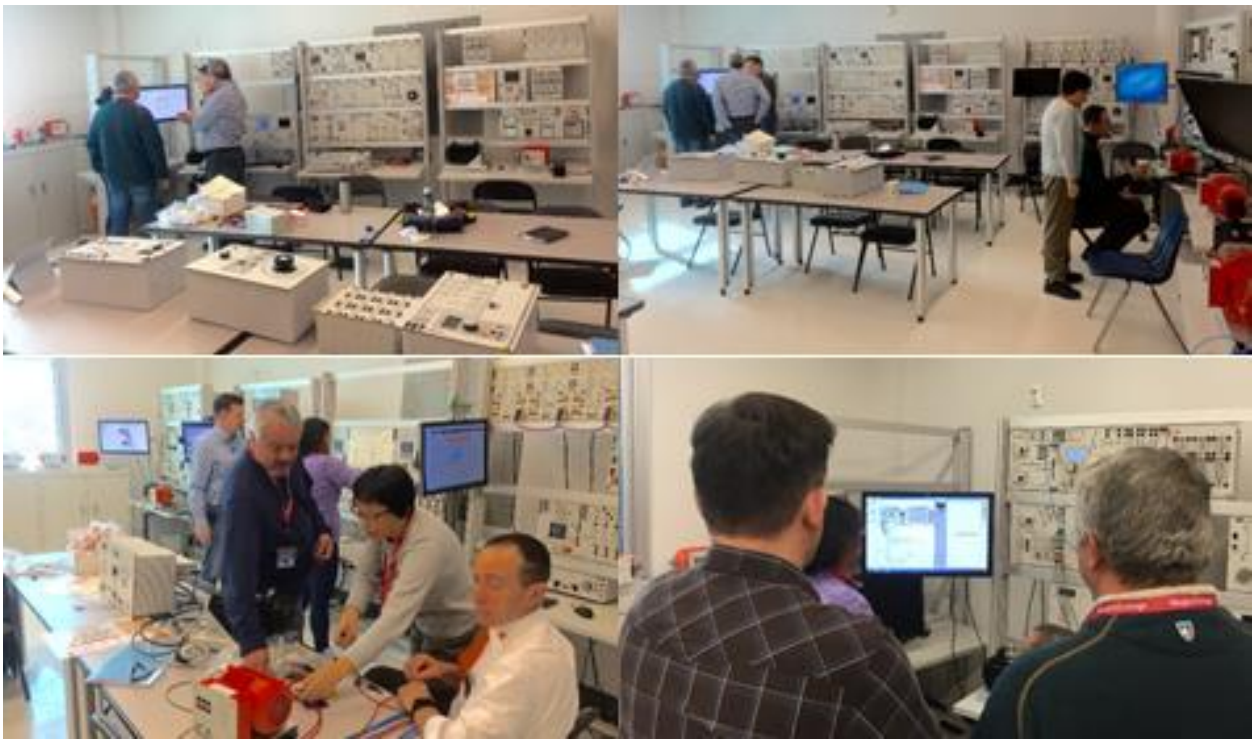
Power Electronics and Power Systems Training course at Vaughn College Smart Grid Power Systems Laboratory

From November 12–14, 2018, Dr. Rahemi organized a three-day (9 am – 4 pm) power electronics & systems training with U.S. Didactic and Lucas-Nulle at Vaughn's Smart Grid Power Systems Laboratory. This state-of-the-art laboratory has been established in fall 2015 with funding support from US Department of Education (Title III HSI-STEM) grant. This lab complements the lecture course in Electromagnetism (ELE323), Electric Machines (ELE325), Power Electronics (ELE451), and Introduction to Power Systems (ELE452).

This training provided four Vaughn's engineering faculty members (Dr. Shouling He, Dr. Mohammed Benalla, Dr. Sundari Ramabhotla, and Dr. Miguel Bustamante) with the hands-on laboratory skills needed for electrical machines, power electronics, motor drives circuits & controllers, as well as contemporary techniques in power generation, power transmission, power distribution, and energy management of load consumption.

On Monday, November 12, Vaughn's faculty received a hands-on training in power electronics and motor drives circuit and controller. On Tuesday, November 13, our faculty members received an insight and hands-on training on items related to three-phase AC power circuits with RLC, real reactive power and power factor correction, three-phase synchronous motor/generator, and power system synchronization. On Wednesday, November 14, the third day of training, Vaughn's faculty members were introduced to items related to transmission line, load management and protection.

The knowledge gained from this training is very helpful in providing our engineering students with the current hands-on skills and enhanced career opportunities needed in this demanding field.



Fall 2018 National Science Foundation (NSF) Grants Conference, New Orleans, Louisiana, November 8-9, 2018

Mohammed Benalla, Assistant Professor; Douglas Jahnke, Assistant Professor; and Natasha Waldron, Grants Manager, attended the Fall 2018 National Science Foundation Grants Conference held in New Orleans, Louisiana. The conference gave insight into a wide range of issues at the NSF such as current funding, new and current policies and procedures, and administrative issues. Program officers gave presentations on up-to-date information about specific funding opportunities.

The main sessions covered new programs and initiatives, future directions and strategies for national science policy, proposal preparation, NSF's merit review process, and conflict of interest policies. There were also a number of breakout sessions exploring specific topics. For example, the Engineering breakout session went into some detail about the NSF programs supporting engineering research in areas such as smart manufacturing, resilient infrastructure, and sustainable energy systems. The Education and Human Resources breakout session was also of interest since it provided information about NSF STEM programs.

Advanced Composite Structures: Fabrication & Damage Repair-Phase 1, Abaris Training, Reno, Nevada, January 7-11, 2019

Professor Douglas Jahnke took the Advanced Composite Structures: Fabrication & Damage Repair-Phase 1 course at Abaris Training in Reno, Nevada on January 7-11, 2019. The course balanced theoretical and practical presentations with hands-on exercises.

The first hands-on exercise was working with prepreg carbon fiber unidirectional tape to explore the effects of orientation; "balance" and "symmetry" in a laminate. Dry glass fabric and liquid epoxy resin was used in an exercise designed to teach fundamental vacuum bagging, bleeder & breather concepts. Mid-week, teams worked with prepreg glass and aramid fiber harness-satin fabrics, along with Nomex® honeycomb and polyurethane foam core materials, making sandwich panel structures, utilizing laminate "nesting" techniques. And finally, basic repair methods and techniques were presented along with a "wet layup" repair in the lab. On the last day, the final repaired part was cut in half for evaluation of the manufactured and repaired panel.

Extensive time was also spent in lecture covering many topics, including:

- History of composites, recent developments and terminology.
- Introduction to advanced composite materials/structures.
- Resin/adhesive systems: thermosets vs. thermoplastics, mix ratios, viscosity, service temperature limits, cold storage requirements/shelf life limits, pot life, etc.
- Material Forms: dry cloth and wet resins vs. prepregs, weave/styles, etc.
- Fundamentals of Fabrication: prepreg cloth handling, ply orientation, layup procedures, vacuum bagging.
- Fabrication Methods: wet layup, prepreg layup, filament winding, RTM, infusion, press molding, pultrusion as well as automated tape layup (ATL) and fiber placement (AFP).
- Curing methods: oven/autoclave/hot bonder cures. Viscoelastic properties.
- Health and Safety Issues: proper handling, personal protection, allergic reactions, waste disposal.
- Introduction to adhesive bonding technology: co-curing vs. secondary bonding, surface preparation, cleanliness, bond line thickness and clamping pressure requirements.
- Principles of Tooling: types of tools, thermal characteristics of various tooling materials.
- Drilling and fastening; proper speed and feed requirements, use of mechanical and adhesive bonded fasteners.
- Primer on repair design; permanent vs. temporary repairs, scarf vs. stepped vs. mechanical patch repair scenarios. Inspection methods & techniques: non-destructive inspection methods, defect detection, documentation, acceptable vs. unacceptable defects, defect prevention.

Overall the course provided a foundation in fundamental theory and techniques of advanced composite manufacturing and repair.

Advanced Composite Structures: Fabrication & Damage Repair-Phase 1, Abaris Training

SWE Vaughn Chapter Holds A Workshop at 2018 SWE Annual Conference
by Niki Taheri, President of Vaughn's Chapter SWE Club

From October 17-20, the Vaughn College chapter of the Society of Women Engineers attended the 2018 Women Engineers Conference in Minneapolis, Minnesota. During the conference, Vaughn's SWE students presented and held a STEM workshop. In addition to participating and presenting at WE18, these students had another item on their agenda: employment. Twelve students from SWE went to the conference in search of internships or full-time employment, and they were quite successful. Together they received a combined 34 interviews with such industry leaders as Northrop Grumman, Boeing, Lockheed Martin, Daimler Trucks North America, Cummins, Medtronic, NASA JPL and Raytheon. In addition, 6 internship positions and 5 full-time positions were offered.

From left to right, the WE18 attendees are Raphael Cordina, Samantha Maddaloni, Samantha Vitez, Sagufta Kapadia, Grace Davis, Niki Taheri, Yarelys Vazquez Marquez, Christina DeLuca, Atif Saeed, Stephanie Palacios, and Aderet Pantierer

Name	Year	Companies	Internship Offer	Full Time Offer
Niki Taheri	Senior	Cummins		**Yes**
		Boeing		
		Medtronic		**Yes**
		John Deere		**Yes**
Sam Maddaloni	Senior	Daimler (SC)		**Yes**
		Daimler (OR)		**Yes**
		Siemens		**Yes** (SWE17)
		John Hopkins JPL		
Grace Davis	Junior	Eaton (Intern)	**Yes**	
		Rockwell Collins	**Yes (Co-op)**	
		Northrup Grumman		
		Boeing		
		Ingersol Rand	**Yes**	
Atif Saeed	Junior	Lockheed Martin	**Yes**	
		NASA JPL	**Yes**	
Sagufta Kapadia	Junior			
		Daimler (OR)	**Yes**	
		Boeing		
		Lockheed Martin	**Yes**	
Raphael Cordina	Junior	Ford		
Yarelys Vazquez Marquez	Junior	Bechtel	*pending*	
		Daimler (OR)	*pending*	
Stephanie Palacios	Junior	Osh Kosh	*pending*	
Aderet Pantierer	Junior	Boeing	**Yes**	
Kirei Watson	Senior	Harris Corporation		***Yes***

Due to last year's Conference and success with internships, this year, Samantha Maddaloni received a full-time offer from Siemens, Lovedeep Kaur is working at Sikorsky Aircraft a Lockheed Martin Company, Maia Rivers is working at Oshkosh, and our previous President, Emily German, is now working at Daimler Trucks North America.

Vaughn's SWE members, Samantha Vitez and Raphael Cordina hosted, "Stop Being Silly!" to a full house. This lightning talk explored ways to empower young women to realize their dreams and aspirations and to do so without being 'silly'. They received 5 stars for their original presentation.

Samantha Vitez and Raphael Cordina present "Stop Being Silly!" during the WE18 conference in Minneapolis, MN.

On Saturday, October 20th, the Invent It. Build It. Expo was held for K-12 students to experience the creativity and innovation of engineering through hands-on projects alongside experienced professional engineers. SWE hosted a STEM mini-piano workshop which taught students the basics of circuitry while also learning about Vaughn College.

Vaughn's SWE members host a mini-piano workshop at the Invent It. Build It Expo at WE18 in Minneapolis, MN

SWE would like to sincerely thank the President of Vaughn College, Sharon DeVivo, the Chair of the Department of Engineering and Technology, Dr. Hossein Rahemi, the Assistant Vice President of Development and Alumni Affairs, Michael Brady, the Executive Director of Career Services, Philip Meade, the Associate Director of Career Services, Jessica Caron, the Assistant Director of Student Activities, Sarah Tsang, and SWE's adviser, Dr. Shouling He for their constant support for SWE activities. I would also like to thank Samantha Maddaloni, Samantha Vitez, Sagufta Kapadia, Grace Davis, Yarelys Vazquez Marquez, Christina DeLuca, Atif Saeed, Stephanie Palacios, Aderet Pantierer, and Raphael Cordina for their hard work in preparing for the conference. The conference would not have been such a success without their remarkable efforts.

Southern Biomedical Engineering Conference, 35th Annual meeting, Hattiesburg MS, February 22-24, 2019

Two Vaughn engineering students, Raiyan Mohammed and Abdullah Ali, along with Assistant Professor Mohammed Benalla participated in the 35th Southern Biomedical Engineering Conference at the University of Southern Mississippi, Hattiesburg MS.

Dr. Benalla chaired a session of Computational bioengineering, Saturday Feb. 23rd from 10 AM to 12 PM. Raiyan Mohammed and Abdullah Ali gave two oral presentations Friday Feb. 22nd. Both presentations were in the critical therapeutics session between 4 PM and 6PM. The first presentation "Brain Controlled Prosthetic Arm" was given by Raiyan and the second "Motion Tracking Robotic Arm," was given by Abdullah. A paper was also submitted related to the first presentation.

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

COE 2019 Annual Experience and Technical Fair

On February 24-27, 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 COE 2019. 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 for the American Helicopter Society (AHS) Micro Air Vehicle student challenge.

On Wednesday February 27, Judges selected Vaughn's team project as the First place award recipient of the COE 2019 poster session competition, involving more than twenty teams.

Vaughn's Team Project Presentation during Tuesday Evening Networking Reception

Vaughn's Team Project Wins 1st Place Award for the Student Poster Session

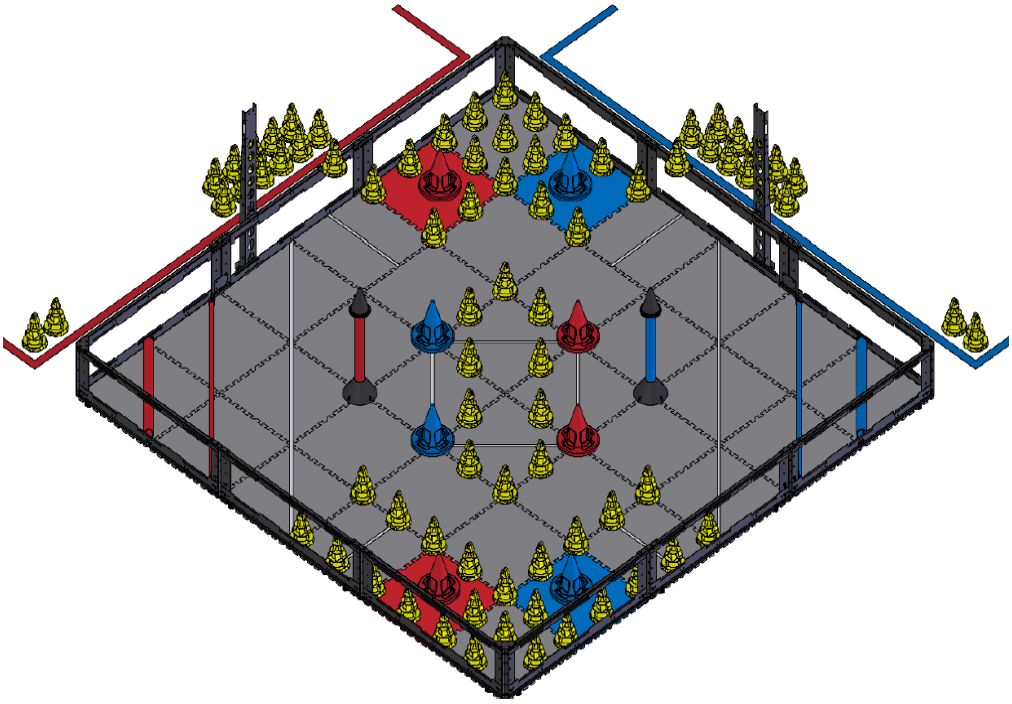
The COE 2019 Annual Experience and TechniFair is a three day event held to bring together expert users of Dassault Systèmes solutions. Students had the opportunity to attend keynote presentations from industry leaders, see the latest product developments, learn solutions to business challenges, connect with experts during networking receptions and visit the TechniFair, featuring more than 30 vendors.

2018 VEX U Robotics World Championship Competition "VEX In the Zone Game"
Vaughn Robotics Team advances to the quarter-final of playoff round in 2018 VEX U Robotics World Champion

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 In the Zone 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 that can perform fast with an effective mechanism to pick up the mobile base and stack coins on the top through both autonomous driver-controlled modes.
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.

For "VEX In the Zone" game, two teams (two Alliances; one red and one blue) compete in each match and the objective is to stacking cones on mobile goals and place them in far, mid, and near zones in the forty-five second autonomous period followed by a one minute and fifteen second (1:45) driver-controlled period. The alliance with the higher score wins the match. The Figure below is an illustration of "VEX In the Zone" starting configuration.



From April 25-28, Eighty-Seven national and international universities and colleges were invited to the 2018 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

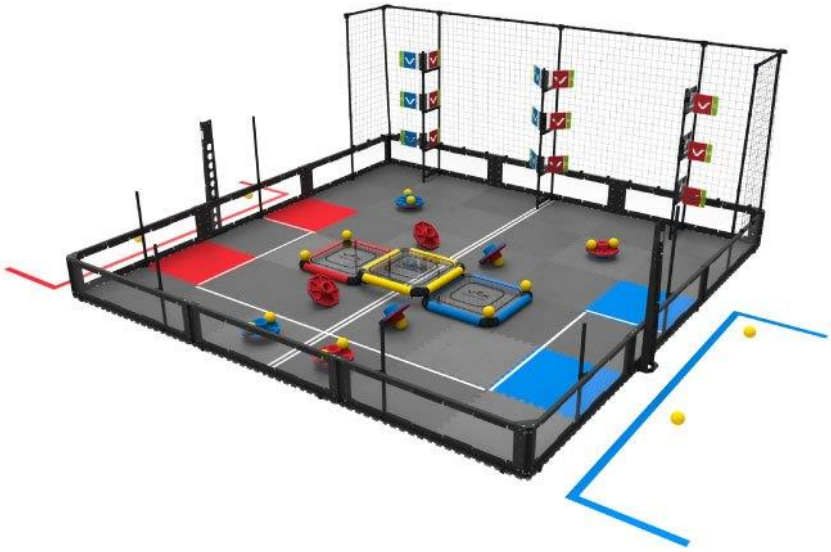
tournament Champion, Finalist or "Excellence" award recipient of a regional competition, and Vaughn's Robotics teams (VCAT and VACT2) were tournament champions of the Vaughn College Regional Robotics Competition, finalists in the West Virginia regional Qualifier, as well as tournament Champion of the Mexican VEX U Reeduca International robotics competition.

This intense three-day competition was challenging, and our teams (VCAT and VCAT2) were continually modifying their robots and autonomous programming to be competitive with other top teams in this tournament. During Thursday VCAT2 team from "Design" division had some overheating issues and the Friday session VCAT team from the "Innovate" division encountered mechanical problems with their robot. Both teams were able to resolve these issues and continue with their qualification matches. Each team in their division had a total of 10 qualifying matches; VCAT2 team from "Design" division won six out of its 10 matches and VCAT team from "Innovate" division won seven out of its 10 matches, advancing to the Saturday afternoon playoff round. During single elimination in the playoff round, the top 16 teams competed, and Vaughn's team defeated a top ranking team from Mexico (number one in "Innovate" division) and advanced to the quarter-final. After the first playoff match, judges informed our team they would be continuing on the blue alliance side throughout the playoff round and our team adjusted their autonomous accordingly; however, at the start of the quarter-final match they announced that since VCAT eliminated the top team (red alliance team), they need to be on the red alliance side. The team did not have enough time to adjust their autonomous as a red alliance and in a close scoring match they lost to a team from Mason.

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 their robots in earlier matches, they were able to overcome these problems and retain their standing as one of the top competitors (top eight teams) in the world championship by advancing to the quarter-final of playoff round of this intense competition for the fifth year in a row.

2018 VEX U "VEX In The Zone" Robotics World Championship Competition

2018-2019 Robotics VEX Turning Point Game



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, 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

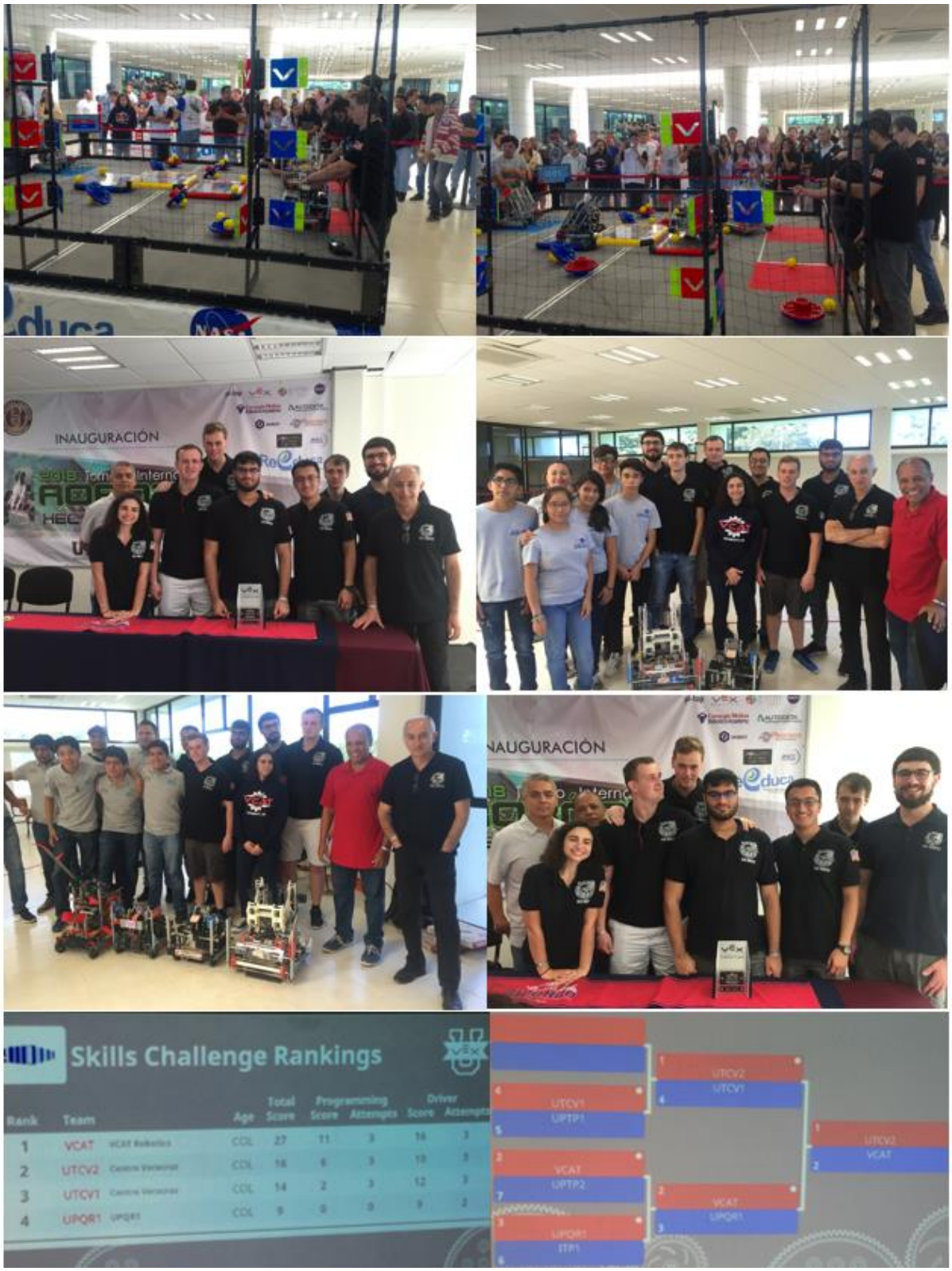
The Details: There are eight (8) Caps, six (6) Posts, nine (9) Flags, twenty (20) Balls, two (2) Alliance Platforms, and one (1) Center Platform. Each robot will have one (1) Ball available as a Preload prior to the match. Caps can be Low Scored on the field tiles, or High Scored on Posts, for the Alliance 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, 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 most total points at the end of the Autonomous Period.

Mexico's VEX U Signature Reeduca Robotics Competition

The Vaughn College Robotics team, one of the top three competitors in VEX U Robotics world championship, was invited to participate in Mexico's VEX U Reeduca Robotics competition as part of the 2018 **Torneo Internacional de Robotica VEX-Reeduca.** From November 21-23, Vaughn College Robotics participated and competed in this Signature VEX U Challenge competition in the Univeredad Politecnica De Quintana Roo, Cancun, Mexico. Seven members of VCAT robotic club (Niki Taheri, Jason Becker, Juan Rodriguez, Atif Saeed, John Hernandez, Eric Grieco, and Andriy Belz) and two advisors, Dr. Hossein Rahemi and Prof. Khalid Mouaouya, represented Vaughn College at this competition.

The competition was challenging; during Thursday November 22 qualifying competition, VCAT team competed against 5 Mexican teams and Vaughn's team won 4 out of its five matches. Vaughn's team won all four of its Friday morning qualifying matches and with a total of eight wins out of nine qualifying matches advanced as 2nd top sitting to the playoff round. In their quarterfinal match the team won against Universidad Politécnica de Tapachula and also eliminated Universidad Politécnica de Quintana Roo during the semifinal match. After hard work advancing to the finals, Vaughn's team lost to Universidad Tecnológica del Centro de Veracruz (VCAT—13, UTCV2—15) in a close match. The team finished Second place overall in the competition and earned First place for the Robotics Skills (Programming and driving skills) Champion category and is currently first in the world in the Skills category. For the past four years, Vaughn robotics team members consistently demonstrate persistence and drive in order to attain their title as champions and top competitor of Mexico's VEX U Robotics competition.

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.



Mexico's VEX U Reeduca Robotics competition, November 23, 2018
Vaughn Robotics Team wins Robotics Skills

Vaughn College hosted VEX U Robotics Tournament on Friday, February 8th, 2019; Vaughn Robotics Team wins 2019 VEX U Skill Challenge and Excellence Awards

Vaughn College of Aeronautics and Technology hosted its fifth VEX U College Regional Robotics competition on Friday, February 8th, 2019. A total of four college teams participated at this event. The participant teams included Aquidneck Island Robotics (AIR), New York Institute of Technology (NYIT2), SUNY Sullivan (SULLI1), and Vaughn College of Aeronautics and Technology (VCAT).

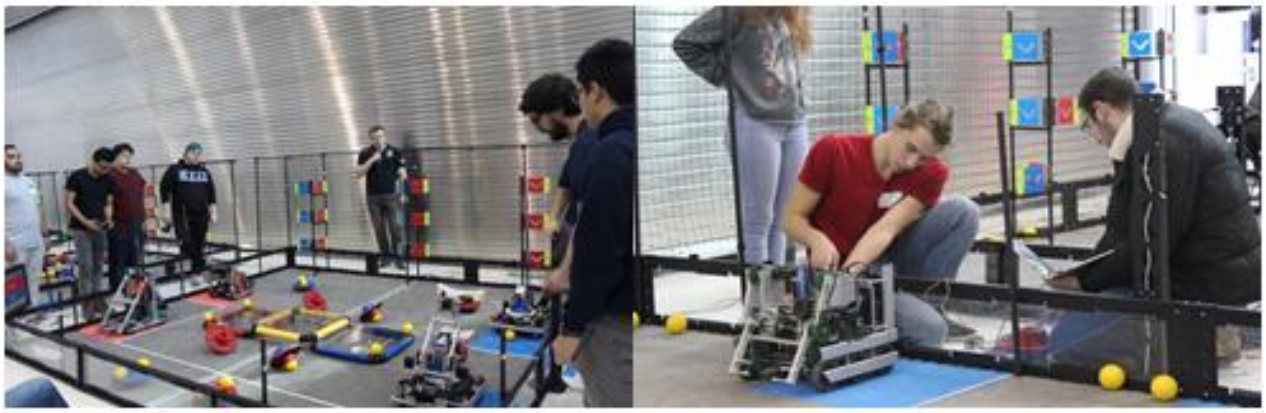
Four members of Vaughn College robotic club (Atif Saeed, Jason Becker, Juan Aguirre, John Hernandez, Eric Grieco) represented the Vaughn team (VCAT) at this competition. Also, Crowley and Maharshi served as referees, and Missael and Jason served as the event manager. Andriy Belz served as announcer, while Niki Taheri, Charles Kwon and Nizamadeen Khedaru and other Vaughn's robotics team members were involved with Robots inspection, setting up the fields and facilitating the implementation process for this event. Also, Dr. Ducharme and Prof. Dash served as judges for this competition.

During the skills challenge matches, Vaughn's team finished first in "Robot Skills" (29 points). Each participating team had a total of ten matches. With seven wins Vaughn's team received second ranking in qualification matches and advanced to the playoff elimination round. The Tournament Champion of this Competition was AIR winning by 1 point in the Finals Match with a score of 16-15.

In this regional completion, Vaughn's robotics team won first place Skills' award and Excellence award.

VCAT Preparing for Matches

Judges Interviewing teams VCAT and NYIT



Matches during VEXU Competition

All participants of the VCAT VEXU Tournament

Vaughn College Hosted VEX High School Robotics Qualifier Competition on Saturday, Feb 9th, 2019

Vaughn College of Aeronautics and Technology hosted its fifth high school robotics competition on Saturday February 9th, 2019. A total of 46 regional high schools from Queens, Brooklyn, Bronx, Nassau, and Suffolk counties attended the January VEX state qualifier at Vaughn College. The list of high school participants is as follows:

Team List

Team	Team Name	Organization	Location
699E	Atomic Empire	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	Redemption	Thomas A. Edison CTE High School	Jamaica, New York, United States
1312A	ER Rockbots	East Rockaway Schools	East Rockaway, New York, United States
1353C	VEXcalibur	Farmingdale High School	Farmingdale, New York, United States
1353P	VEXistential Crisis	Farmingdale High School	Farmingdale, New York, United States
6277A	RoboCavs	The Harvey School	Katonah, New York, United States
6277B	RoboCavs	The Harvey School	Katonah, New York, United States
6277D	RoboCavs	The Harvey School	Katonah, New York, United States
9458A	Robo Chiefs	Massapequa School District	Massapequa, New York, United States
9458B	Robo Chiefs	Massapequa School District	Massapequa, New York, United States
9458C	Robo Chiefs	Massapequa School District	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
9932A	Hawks	Jericho High School	Jericho, New York, United States
9932E	Hawks	Jericho High School	Jericho, New York, United States
9932F	Hawks	Jericho High School	Jericho, New York, United States
9932G	Hawks	Jericho High School	Jericho, New York, United States
9932H	Hawks	Jericho High School	Jericho, New York, United States
11040A	HighlandBots	Herricks High School	New Hyde Park, New York, United States
11040B	HighlandBots	Herricks High School	New Hyde Park, New York, United States
15239A	RoboBaller	RoboBaller	Somers, New York, United States
16099A	Overclock	KG Computech	Flushing, New York, United States
16099B	Overclock	KG Computech	Flushing, New York, United States
16099M	Overclock	KG Computech	Flushing, New York, United States
17777A	LFNY	Lycee francais de new york	New York, New York, United States

17777B	LFNY	Lycee francais de new york	New York, New York, United States
19396A	Bayside	Bayside High School	BAYSIDE, New York, United States
19396B	Bayside	Bayside High School	BAYSIDE, New York, United States
25565A	Seven	Riverdale Country School	BRONX, New York, United States
25565B	Seven Point One	Riverdale Country School	BRONX, 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
39255B	Hawks	Hillcrest High School	Jamaica, New York, United States
62880A	LISG Robotics	Long Island School For The Gifted	HUNTINGTON STATION, New York, United States
68602A	GC Robots		Garden City, New York, United States
68602B	GC Robots		Garden City, New York, United States
68602C	GC Robots		Garden City, New York, United States
76194A	Dragons	Division Avenue High School	Levittown , 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
99588A	PIA TECH LEAGUE - A	PIA TECH LEAGUE	Great Neck, New York, United States
99588B	PIA TECH LEAGUE - B	PIA TECH LEAGUE	Syosset, New York, United States
99588C	PIA TECH LEAGUE - C	PIA TECH LEAGUE	Syosset, New York, United States
99588X	PIA TECH LEAGUE - X	PIA TECH LEAGUE	Syosset, 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; Andriy Belz served as the announcer. Vaughn faculty members, Prof. Khalid, Prof. Dash, Prof. Goya, Luis Santa, Dr. He, Prof. Wermert, Prof. Jimmo, Dr. Benbelkacem and Prof. Sypeck served as the judges for this competition.

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

The table below provides the list of award recipients for the 2019 regional High School VEX Robotics State Qualifier Competition. 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" Winner qualified to participate in the New York State VEX Championship.

Award	Team #	Team Name	Affiliation	Location
Excellence Award (VRC/VEXU)	16099A	Overclock	KG Computech	Flushing, New York, United States
Tournament Champions (VRC/VEXU)	97871A	Roverines Robotics	Newfield High School	Selden, New York, United States
Tournament Champions (VRC/VEXU)	1353P	VEXistential Crisis	Farmingdale High School	Farmingdale, New York, United States
Innovate Award (VRC/VEXU/VIQC)	16099A	Overclock	KG Computech	Flushing, New York, United States
Create Award (VRC/VEXU)	25565A	Seven	Riverdale Country School	BRONX, New York, United States
Build Award (VRC/VEXU)	15239A	RoboBaller	RoboBaller	Somers, New York, United States
Design Award (VRC/VEXU)	9932F	Hawks	Jericho High School	Jericho, New York, United States
Judges Award (VRC/VEXU)	99588C	PIA TECH LEAGUE - C	PIA TECH LEAGUE	Syosset, New York, United States
Tournament Finalists (VRC/VEXU)	99588A	PIA TECH LEAGUE - A	PIA TECH LEAGUE	Great Neck, New York, United States
Tournament Finalists (VRC/VEXU)	99588B	PIA TECH LEAGUE - B	PIA TECH LEAGUE	Syosset, New York, United States
Robot Skills Champion (VRC/VEXU)	16099A	Overclock	KG Computech	Flushing, New York, United States
Energy Award (VRC/VEXU)	699E	Atomic Empire	Thomas A Edison Career And Technical High School	JAMAICA, New York, United States
Sportsmanship (VRC/VEXU)	15239A	RoboBaller	RoboBaller	Somers, New York, United States

2019 New Hampshire VEX U Robotics Regional Qualifier Competition, February 23, 2019

On Saturday February 23, 2019, Vaughn College's Robotics team participated at the New Hampshire VEX U Robotics Regional Tournament. The team was composed of thirteen members (Eric Grieco, G Juan Aguirre, Jason Becker, Niki Taheri, John Hernandez, Atif Saeed, Andryi Belz, Charles Kwon, Rashid Bilal, Manny Duenas, Timothy Tullio, and Nicholas Harrington)..

A total of eight colleges and universities participated in the event. The participant teams included two teams from Manchester Community College (MCC1 and MCC2), Johnson & Wales University (JWU1), Worcester Polytechnic Institute (WPI), New York Institute of Technology (NYIT3), Vermont Technical College (VTC1), Aquidneck Island Robotics (AIR), and Vaughn College of Aeronautics and Technology (VCAT).

Each participating team had a total of six matches. Vaughn's team won all of its six qualifying matches and advanced to the 1st place seating of the playoff round. During the elimination of playoff rounds, VCAT defeated all of their opponents thus advancing to the finals where they faced AIR. In an intense final game of tournament matches; VCAT won the match (VCAT 16, AIR 10). In this regional competition, Vaughn's robotics team finished first and won both first place "Robot Skills" and "Excellence" awards which qualifies the team to participate in the 2019 VEX U World championship.


VCAT
VEX
Excellence Award
REGIONAL
CHAMPIONSHIP
2019

2019 West Virginia VEX U Robotics Regional Qualifier Competition, March 1, 2019

On Friday March 1, 2019, Vaughn College's Robotics team participated at the Fairmount State University VEX U Robotics Regional Tournament. The team was composed of ten members (Juan Aguirre, Jason Becker, Niki Taheri, John Hernandez, Atif Saeed, Charles Kwon, Timothy Tullio, Eric Grieco, Maharshi Patel, and Joseph Crowley) along with department chair, Dr. Hossein Rahemi.

A total of fifteen colleges and universities participated in the event. The participant teams included two teams Rutgers (RUSK1), University of Maryland Baltimore (UMBC), NJIT, & Wales University (JWU), one team from College of Southern Maryland (CSM), Aquidneck Island Robotics (AIR), NYIT, Purdue University (BLRS), Michigan State University (MSU), Kennesaw State (OWL1 & OWL2), Loyola (LOYOL1), CTU, NOVA, and Vaughn College of Aeronautics and Technology (VCAT).

Each participating team had a total of six matches. Vaughn's team won four of its six qualifying matches and advanced to the playoff round. During the quarterfinal of playoff rounds, VCAT defeated NYIT and advanced to the semifinal. In an intense semifinal match, VCAT team lost to a team from Purdue University (BLRS). Vaughn's robotics team won the Design award of this regional competition.

VCAT team won the design awards of 2019 West Virginia VEX U regional competitions

Vaughn's Society of Automotive Engineers
Vaughn Motorsport Formula SAE: Racing into the Future

Vaughn Motorsport is a not-for-profit student club embracing future engineers, technicians and enthusiasts, and guiding them through all facets of motorsport and motoring, from competitions to educational development and social experiences. President and club founder Sam Vitez '21, a mechatronic engineering major, says it best, "We extend to Vaughn students who display passion, initiative and curiosity, the opportunity to live out their values through applied education, community development, thrilling events and a small dowsing of competitive spirit." Vitez worked with Engineering and Technology Department Chair Dr. Hossein Rahemi to determine what support the club would need to design, build and enter the competition. Rahemi was able to support their goals by utilizing funding from a federal Hispanic-serving institution science, technology, engineering and mathematics (STEM) grant from the Department of Education.

Now, for the first time under the Vaughn Motorsport umbrella, the team aims to test its education and put to real-world use its skill sets in the national competition, Formula SAE (previously known as the Society of Automotive Engineers). To do so, Vitez is developing another club with several other members, tentatively named the Vaughn Race Engineering Division, to compete in the competition.

Formula SAE is a student design competition started in 1980. The concept behind Formula SAE is that a fictional manufacturing company contracts a student design team to develop a small Formula-style race car from the ground up. Each student team designs, builds and tests a prototype based on a series of rules, which aim both to ensure on-track safety (the cars are driven by the students themselves) and to promote clever problem-solving.

This competition encompasses all aspects of a business, including business plan development, research, design, manufacturing, testing, marketing, management and fundraising. The winners are chosen by experts from motorsports, automotive, aerospace and supplier industries based on student design, cost and sales presentations.

"Formula SAE pushes us to apply what we have learned in the classroom to a real-world project," says Vitez. "Having the opportunity to oversee and complete the design of both specific parts and overall systems provides Vaughn Motorsport an unparalleled experience of seeing a high-level project to completion. We're excited by the challenge and are focusing on racing in 2019."

"This effort expands our engineering clubs' capabilities into the area of manufacturing by allowing our students to apply the knowledge they learn in their program to build a real engineering system. Through this hands-on team project they gain a better understanding of how a gear system, transmission shafts, and a motor work, while developing the necessary skills to be competitive in the manufacturing and automotive industries. The creative mindset acquired through this experience will make them the future innovators of tomorrow. This is another example of how Vaughn provides hands-on opportunities to supplement theoretical learning, making our students future-proof," says Rahemi.

Vaughn Motorsport

While Vaughn Motorsport and the Vaughn Race Engineering Division are new additions to Vaughn, its team members are committed to benefiting the students, the College and the community. They lead workshops, hold events such as monthly car meets and organize trips to local raceways. They hold programs for children to participate in science, engineering, technology and mathematics (STEM)-focused workshops with an emphasis on automotive knowledge, teaching the physics and mechanics of the car. In addition, during the summer months, Vaughn Motorsport has set up a mentor program with Flushing Meadows Soap Box Derby, so children from the community get a chance to go to Akron, Ohio, for the finals.

The 2019 Formula SAE competition is being held May 8 through May 11 in Brooklyn, Michigan, at the Michigan International Speedway.

2018-2019 Vaughn's SAE Club Activities

The newly founded SAE team has been working tirelessly to establish a name for themselves. In its founding semester, Fall 2018, it attracted over 50 members. Since then, it has set out its eyes on the Formula SAE Michigan 2019 competition, a collegiate design and fabrication competition of a Formula-style racecar. All stages of the competition design and fabrication are entrusted solely to the students. The preparation for this competition gives the members firsthand experience with concepts and problems within the industry. From research and development to economic analysis and budgeting, this competition encompasses every aspect entailed in a job in this field.

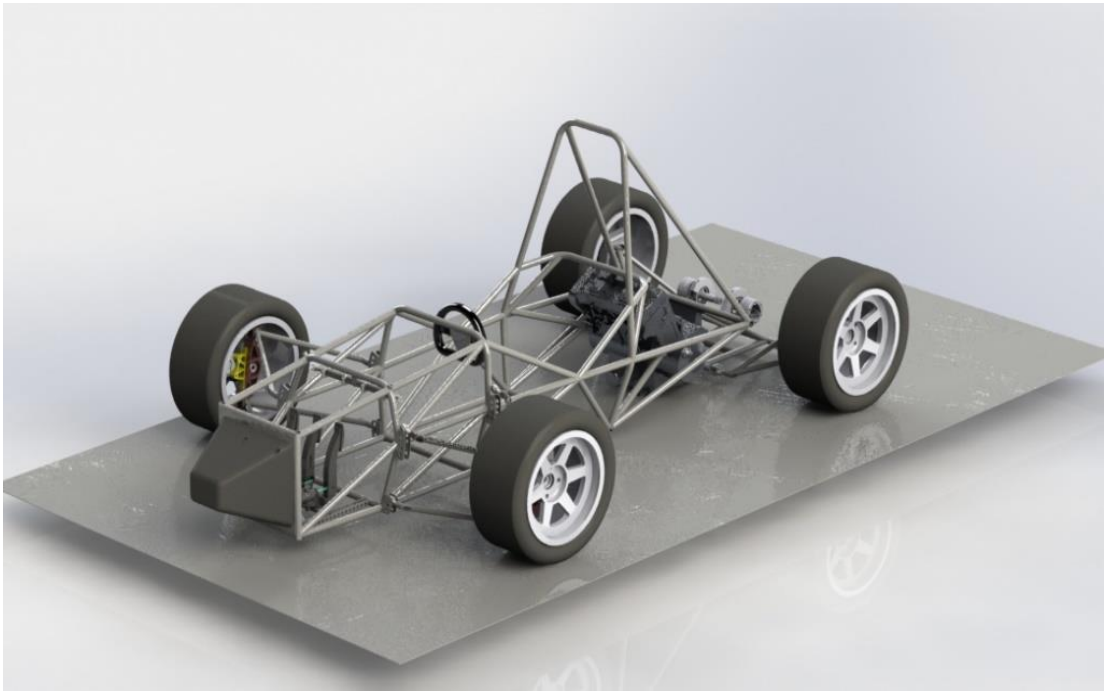
In order to prepare for this competition, as well as to build teamwork and camaraderie, the team members participate in club-run workshops to develop the skills needed to compete.

Members have been building confidence in their CAD skills by designing various components which also aid the team outside of the competition. A handful of members designed various equipment for the workshop to create a more conducive work environment. For instance, bar stools for the shop workbench were designed and analyzed in SolidWorks to withstand the weight of an average student. With the design completed, the stools are set to be built using recycled tubing from a previous chassis design. Future workshops are planned, including a welding workshop where members will be trained to use a TIG welder, and various commercial car maintenance workshops.

The design of the racecar is divided into four major disciplines: chassis, powertrain, suspension, and electronics, and members engage in these disciplines, based on their interests.

Chassis Development:

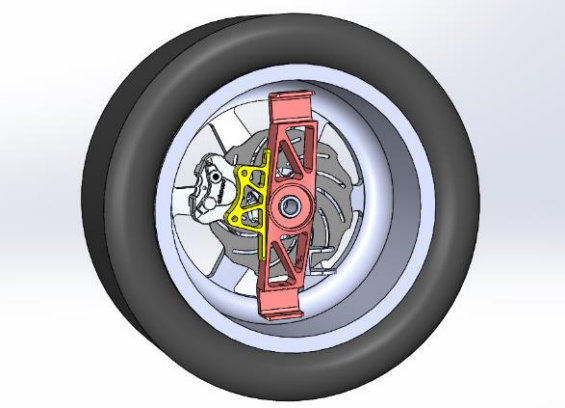
Adhering to the precise competition regulations, an initial chassis design was modeled and analyzed in SolidWorks. These CAD skills were developed in classes offered by the school as well as club workshops. Both the school and the workshops have enabled the members to establish a strong background in research and design in multiple CAD software which is beneficial in future work in the industry. The competition rules were precise about the chassis being designed to accommodate a male within the 95^{th} percentile of height, driver position template, proper triangulation, specific components geometry and stiffness, and many other specifications. Through meticulous attention to detail, the chassis was thoroughly analyzed and reanalyzed to ensure it was safely designed. Moving forward, the chassis will be fabricated using a chassis jig designed by team members who will be tasked with creating engineering drawings of the chassis and of each of the car's geometry components.



Powertrain Development:

Powertrain encompasses multiple components of the car, including the engine management, transmission, differential, and axles. The team is using a 2002 Honda CBR600F4i engine which will be incorporated into chassis structure so the components can be designed around each other. These collaborative modifications include redesigning the oil system in order to lower the engine and thereby lower the center of gravity which aids the handling characteristics of the car.

Suspension Development:



Suspension also has a wide range of required elements. Suspension is a design aspect encompassing the fewest components but requiring the most calculation and analysis. Chassis and suspension collaboration is imperative, because the geometry of the suspension is directly correlated to the geometry, mass, and key location of certain chassis members. Designing and modeling of the hubs and the uprights is currently in progress, and these parts are essential to the development of an operating suspension system.

Electronics Development:

The main task of the members involved in electronics development is to create a wiring diagram that maps the connections of all the electrical components. Wires were taken from the motorcycle engine but are being reconfigured to accommodate the additional parts of the car, as well as the lacking components of the motorcycle.

As the competition grows nearer, all members have been working tirelessly to create a car that will make Vaughn College proud. With the hard work and efforts of all the team members, the car will be complete in time to race in the May competition.

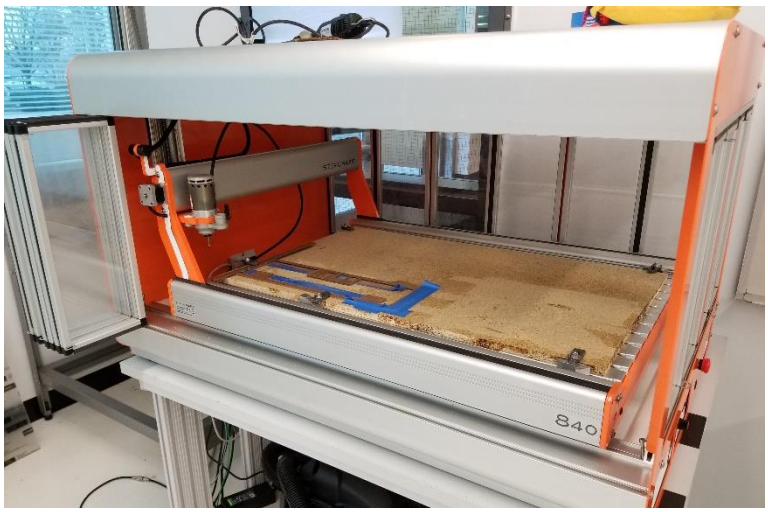
2018-2019 Vaughn's UAV Club Activities

Since the founding of the UAV Club, the organization has been primarily focused on multicopters; small unmanned systems capable of vertical take offs and landings. After a victory at the annual Vertical Flight Society Micro Air Vehicle competition held in Phoenix Arizona, members began looking for more challenges and opportunities to put their skills to the test. As a result, in the 2018-2019 season, the UAV Club began preparing to compete in the Student Unmanned Aerial Systems (SUAS) competition hosted by the Association for Unmanned Vehicle Systems International (AUVSI). Due to the scope of this challenge, the UAV Club will begin development of unmanned fixed-wing aircraft capable of long-range flight while being capable of carrying large mission-critical payloads.

The AUVSI-SUAS 2019 challenge is a multi-part student challenge open to high school and college teams. The challenge includes waypoint following, obstacle avoidance, package delivery, object identification, and classification. The purpose of the competition is to develop an autonomous UAV system capable of search and rescue and package delivery to aid search and rescue workers. In order to complete this challenge, the

UAV Club will develop an autonomous system capable of downloading pre-defined missions, executing them autonomously and reporting back to base with information concerning detected objects on the ground. This system will be paired with a long-range tracking system which improves reliability over long distances.

We pride ourselves on our ability to rapidly prototype and manufacture custom made parts. With the purchase of a Stepcraft 840 CNC machine, UAV club members are given the opportunity to learn the core concepts of subtractive manufacturing. This, along with 3D modelling skills and our 3D printing lab allows us to model and manufacture parts quickly.



STEM Outreach Activities: Contribution to the community is one of the most important values held by the UAV Club. Throughout the year the UAV Club hosts various workshops and events to educate the community about the UAV world. In the Fall 2018 semester alone, the UAV Club held three different workshops. These workshops included the Bi-Directional motor control workshop, the Programming an OLED Display workshop, and the Building a drone workshop. The Bi-Directional motor control workshop was held for a group of girl scouts, in which they learned about how an electronic speed controller is used to make a drone and they also had the opportunity to build and program a motor controller using a motor, potentiometer and an Arduino Nano board along with various electronic components. Another workshop, Programming an OLED Display was held for a group of high school students and educated the participants in the programming basics crucial

to developing an autonomous drone. In this workshop the students were informed how an OLED Display can be programmed to display various information. Then, on Vaughn's annual Manufacturing Day, the UAV Club held the Building a Drone workshop, in which the attendants were given a brief presentation on the basics of drone building,and then they were given parts to build a small drone for themselves.

The UAV Club also hosts events such as International Drone Day and Tiny Whop races and the club also presents at various events. International 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 booth, 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.

Another major event is the Tiny Whoop Race, at which the UAV Club sets up an obstacle course at the ATI Building of Vaughn College and invites drone enthusiasts to race their Tiny Whoops and show off their skills. This event is also open to anyone interested in attending. Additionally, in Fall 2018 the UAV Club presented at the Cradle of Aviation Museum and at an event at the Hall of Science. Through these workshops and events, the UAV Club contributes to the education of many regarding the technological advancements in this field and also inspires the younger generation.

We further increase our community outreach by partnering with organizations such as the Society of Hispanic Professional Engineers (SHPE) and the New York Hall of Science in their annual STEM Fair. Along with many other colleges in attendance, we were one of the most interactive tables present. Children from all ages came and experienced firsthand what it feels like to fly a drone in First-Person-View (FPV), and they learned how to build their first very own Tiny Whoop. Since our team is so diverse, we were also able to accommodate the families who didn't understand English but who wanted to know how to get their child involved.

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."

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 have been a growing number of active members and events that uphold the mission of the organization.

"My Vaughn's Story," Ms. Leonie Barden

On September 20th, 2018, the National Society of Black Engineers hosted a Vaughn alumnus who is a Systems Engineer at Boeing, Ms. Leonie Barden. Ms. Barden gave a remarkable speech about her journey from sitting in the class room to working on space projects for NASA, as well as her continuing 10 years work experience with Boeing. She inspired, motivated and connected with many students who wanted to gain similar success in the engineering field. Ms. Barden generously provided her contact details for mentorship and guidance.

Figure 1: Ms. Barden and NSBE members

NSBE 44th National Convention

The National Convention for NSBE was held in Pittsburgh, Pennsylvania from March 21st, 2018. 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. A few of our members represented our chapter at the convention. This event exposed our members to workshops preparing them to excel academically, succeed professionally, and have 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 300 companies. The career fair also provided members with the opportunity to pursue success in both pre- and post- graduation job opportunities.

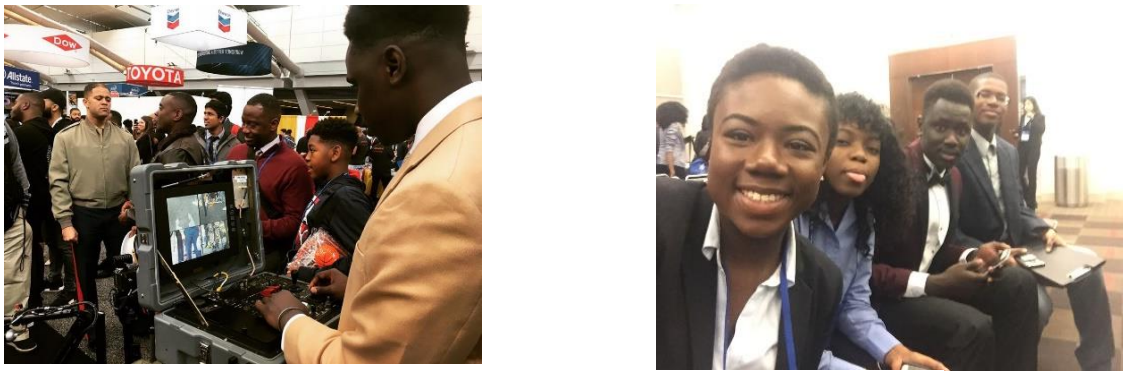


Figure 2: NSBE members at the 44th National Conference

STEM Workshop with Girl scouts of Nassau County, Clara H. Carlson Elementary School.

On December 1st, 2018, The National Society of Black Engineers collaborated with the STEM office at Vaughn College to host workshops for the Girl scouts of Nassau County. Over 15 girls were engaged in STEM related projects. NSBE engaged the girls in building a simple cooling fan project involving soldering techniques and basic physics principles. The girls enjoyed the projects and look forward to returning to Vaughn for more exciting STEM activities.

Figure 3: STEM workshop with NSBE

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 that supports and empowers 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. The chapter also prides itself on its STEM outreach, in hopes of increasing future female involvement in engineering.

Women Engineers 2018 Conference

The Vaughn College chapter of the Society of Women Engineers (SWE) attended the 2018 Women Engineers Conference in Minneapolis, Minnesota from October 17 through October 20, 2018. During the conference, SWE students presented and held a STEM workshop. In addition to participating and presenting at WE18, these students also had employment on their agenda. Twelve students from SWE went to the conference in search of internships or full-time employment, and they were successful. Together this group received a combined total of 34 interviews with such industry leaders as Northrop Grumman, Boeing, Lockheed Martin, Daimler Trucks North America, Cummins, Medtronic, NASA JPL and Raytheon. In addition, they were offered 6 internship positions and 5 full-time positions. Due to last year's Conference and success with internships, this year, Samantha Maddaloni has received a full-time offer from Siemens.

During the conference, Vaughn's SWE members, Samantha Vitez and Raphael Cordina hosted, "Stop Being Silly!" to a full house. This lightning talk explored ways to empower young women to realize their aspirations without being 'silly'. They received 5 stars for their presentation. On Saturday, October 20th, the Invent It. Build It. Expo, was held for K-12 students to experience the creativity and innovation of engineering through hands-on projects alongside experienced professional engineers. SWE hosted a STEM mini-piano workshop which taught students the basics of circuitry.

SWE STEM Outreach

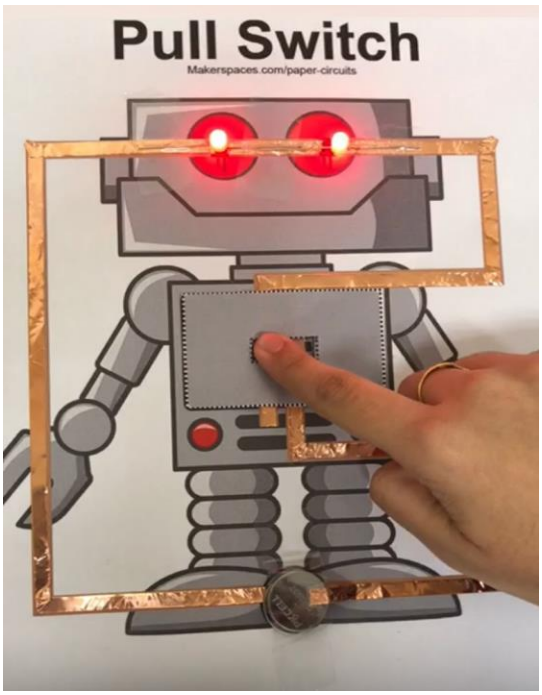
SWE STEM Workshop at World Maker Fair: On September 22nd and 23rd, Vaughn's Society of Women Engineers chapter hosted a Toy Car STEM workshop at 2018 NYC Maker Faire. The purpose of the workshop was to introduce students from K to 12th grade to the world of STEM by showcasing fun products to construct using a theoretical background. These activities use basic concepts of Mechanical Engineering, Electrical Engineering, and Computer Science and bring fields of employment to the attention of young women who otherwise may never consider these fields. These workshops are presented visually, verbally, and kinesthetically to enhance students' overall understanding.

At the booth, a STEM workshop was organized for makers of all ages. Prior to the event, SWE members prepared 175 kits for the event. The SWE workshop did better than we anticipated, and we ran out of the kits on the first day of the event. Through the Maker Faire, SWE was able to make many memorable connections with educators, museums, and other colleges.

The project brought to the Maker Faire was a small circuit with a 3D printed base that created a car as the end product. This project allowed students to learn the basics of circuitry and how a motor works. Students also had the opportunity to see the inside of a motor and learn how it actually works. This workshop was a huge success and SWE is excited to attend the Maker Faire again next year.

Our first STEM Outreach workshop was held by Juan Aguirre on November 17th. He successfully presented the "Light up Car" to 20 middle school Students and explained the electrical engineering concepts needed to understand this project. Students were taught the fundamentals of current and voltage, as well as how to use photoresistors, capacitors, diodes, LEDs, motors and switches. After learning the basics, the students were given step-by-step instructions on how to build their own "Light Up Car". This hands-on process allowed the girls and boys to better

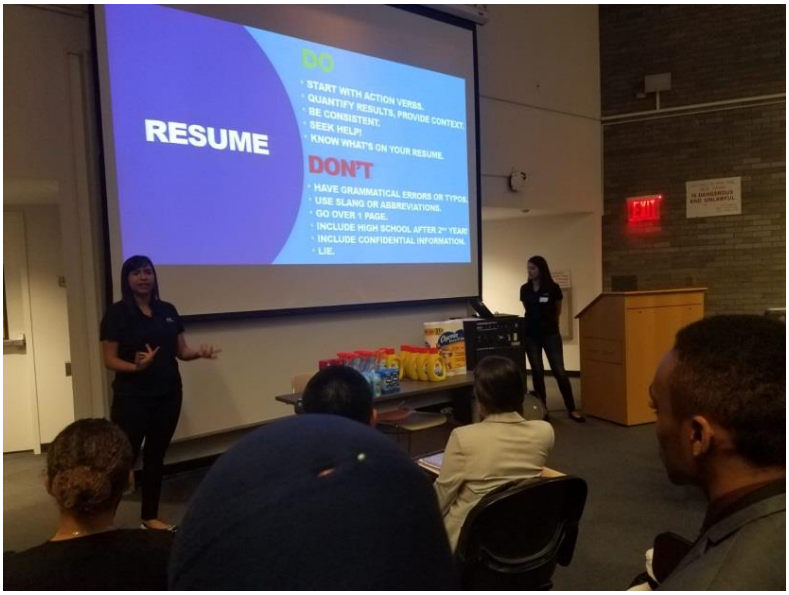
understand what had been previously only demonstrated. The workshop also promoted teamwork and problem-solving skills, important to students wanting to pursue a future in engineering.



Sagufta Kapadia was responsible for holding the "Building a Circuit with Tape" workshop for a group of Girl Scouts (8th-10th graders). She began with a presentation on current, resistance, LEDs and the basics of building a complete circuit. The students were then given explanatory packets and the opportunity to build their own circuit with copper tape. The copper tape was provided as a pathway for the current to flow, so that when the circuit is complete, the LEDs light up. The students were given two templates from which to choose, a robot and a police car. This workshop provided a fun learning experience for the students, and it gave its participants a better understanding of how a conductive material allows the current to flow and how a circuit is completed. Upon completion of the circuit, to test their understanding, the students were asked various questions about what they had learned during the presentation.

Society of Hispanic Professional Engineers (SHPE) Club Activities

<u>Preparation for career – Career Summit</u> *<u>(October, 2018)</u>*



SHPE is a national organization with more than 50 chapters in New York alone. In October 2017 with the help of Darwing Espinal and Vaughn College, SHPE was able to host our own Career Summit. Through this event we were able to learn from professionals what it takes to be an outstanding engineer. In October 2018 SHPE-VCAT partnered up with SHPE-CCNY and created an even bigger Career Summit with more diversity of both students and professionals. Students were able to review, improve and edit their resumes working with employees from GE, EATON and Bechtel, and they also had the opportunity for on-the-spot interviews with HR agents. This event was held prior to the National Convention to get students ready, comfortable and confident while speaking with recruiters.

Meeting Dr. Greg Olsen *(October 2018)*

During Dr. Olsen's visit we got to learn about his path to success. As president of GHO ventures Dr. Olsen shared his passion for new business development, experimentation and design. SHPE along with EWB, SWE and Vaughn College hosted the event to learn more about how people become successful in their fields. Dr. Greg Olsen candidly shared the fact that he made up for a lack of brilliance by being a hard worker.

LatinX *(October 2018)*

LatinX was an event hosted by New York City's Mayor! SHPE-VCAT was directly invited by the mayor to represent young Hispanic engineers. The purpose of this event was to socialize with different Hispanics in all kinds of fields from politicians, lawyers to NYPD's finest musicians. We had a wonderful time seeing our members learn how to dance to traditional music. We got to meet other students from Columbia and Fordham University who had never heard of Vaughn College and were amazed by the work we do in getting our students involved and connected. Bill de Blasio gave a wonderful speech about diversity and the importance of education in STEM. We also had the pleasure of sharing our time with Sarah Tsang and Elaine White.

Dia de los Muertos *(November 2018)*

One of Central American holidays is Dia de los Muertos (Day of the Dead) is an event to celebrate the life of loved ones. The purpose of this event was to create a tighter bond between our members and expose them to different Hispanic cultures. We were impressed to see many of the members from the Robotics team and UAV club join us for this event which made it even more successful in uniting the students from different organizations. Because Dia de los Muertos is right after Halloween we wanted to incorporate American traditions as well and we made a costume competition. Nicolas Ceballos won the competition with his butcher's costume!

Preparation for the National Convention *(November 2018)*

As the National Convention came closer we needed to focus more on our Professional Pillar, so we set social events aside and focused on strengthening the skills and experience we had gathered from October's Career Summit. Vaughn College sponsored 16 SHPE members to attend the National Convention, making it the largest group of students to go to a Career fair outside of Vaughn. This preparation consisted of 4 main workshops, Resume Improvement, Company Research, Applying for Jobs, and Having the Greatest Interview. We practiced Interview Q&A until 30 minutes to an actual interview, and the results were quite positive with 10 out of 16 students receiving offers in their prospective fields.

Nissan Design Competition *(November 2018)*

Out of thousands of SHPE members only 6 students got to present their ideas in the Nissan Challenge. In this competition two students who might never have known each other before work as a team and carry out their presentation. Angel Calderon was accepted into the Nissan Competition. With his knowledge from classes and involvements with other clubs he presented his idea of reducing fuel consumption without sacrificing torque while navigating. The previous year Vaughn won 3rd place with Darwing Espinal's presentation, but this year we received 1st place with Angel Calderon's presentation. After Angel's presentation he got a chance to speak with HR and he was offered an intern position with Nissan.

National Convention *(November 2018)*

Thanks to Vaughn College 16 students received sponsorship to attend SHPE's National Convention in Cleveland, Ohio. Leading since September, SHPE-VCAT took on the role to polish each member whether attending nationals or not. As a result of their hard work, 10 out of 16 students received offers for either full time or intern positions. The following is a list of students and the companies with whom they have chosen to work:

Name	Year	Company	Position Accepted
Abdullah Ali	Senior	Cummins	Full-time Offer
Angel Calderon	Sophomore	Nissan	Summer-Intern 2019
Darwing Espinal	Senior	Raytheon	Full-time Offer
Frandi Cueva	Junior	Toyota	Co-op 2019
Hector Sabillon	Senior	John Deere	Full-time Offer

Jairo Chauca	Senior	Harris	Full-time Offer
Kirei Watson	Senior	Collins Aerospace	Full-time Offer
Nicolas Ceballos	Senior	Sikorsky	Full-time Offer
Robert Escobar	Senior	Turner	Full-time Offer
Yarelys Vazquez-Marquez	Junior	Pratt & Whitney	Summer-Intern 2019

STEM Outreach

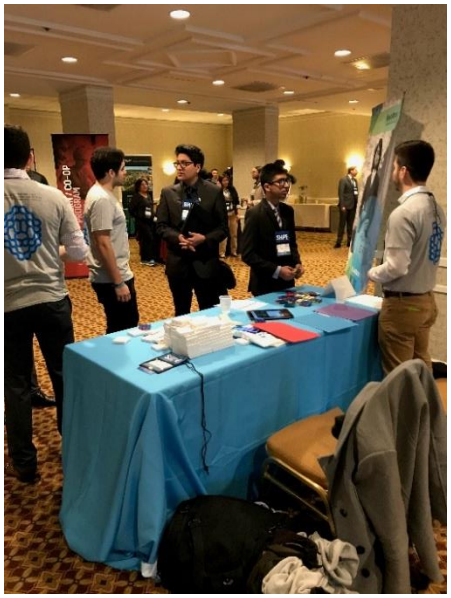
During this academic year our goal was to run 5 STEM activities with students either at Vaughn College or in their school. During the Fall semester 2 STEM workshops were conducted with Vaughn's Upper Bound Program. During these workshops Vaughn College students were able to interact with younger students and foster curiosity for the STEM field. SHPE-VCAT was also part of the Girl Scout's annual STEM event, during which members created a "Bug" that moved by following light. SHPE NYC invites us to participate with them in several Noche de Ciencias which expose all student grades and college students to professional engineers.

Christmas Dinner

Part of SHPE's beliefs is that were all one big family and we support one another in and outside of school; although at times is extremely difficult to get the entire club in one place to come together, we somehow manage to make this happen. This year we focused on leaving a legacy for the club, to remember to be united during exams, to mentor, and to foster a positive attitude among our members.

Regional Leadership Development Academy (RLDC) *February 2019*

New York State is part of SHPE's Region 4 division and this year RLDC took place in Washington, DC. Vaughn College sponsored 5 students to attend this event. RLDC is the perfect place to interact with companies, because of the large numbers of attendees. Companies such as Cummins, P&G, and Raytheon were part of this event and our students had the opportunity to showcase their skills with them during workshops and the career fair.

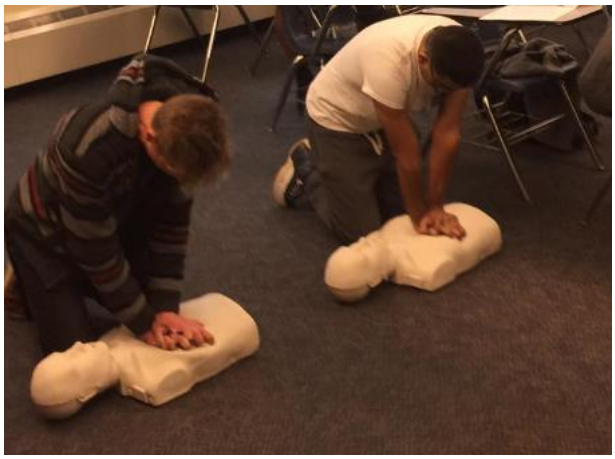


Engineers Without Borders-USA is a national organization that works to create a better world through engineering projects which empower communities to meet their basic needs. The Vaughn College Chapter works to equip the engineering leaders of tomorrow by finding solutions to the developing world's most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

FUNDRAISERS

Engineers Without Borders conducted two fundraisers. The first fundraiser was on campus in October 2018. We made smoothies for Vaughn students, staff, and faculty. This turned out to be a team building experience as we got the opportunity to learn about each other's strengths and weaknesses. Then in November 2018, we proudly partnered with the local Chipotle restaurant to complete our Second Burritos Without Borders. These events allowed new members to take up various team and leadership roles.

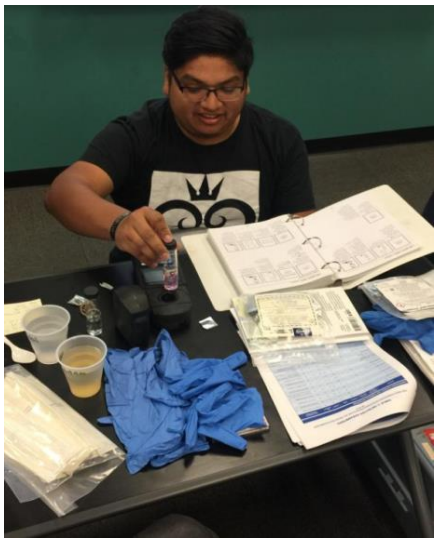
CPR CERTIFICATION



Nationwide Health LLC provided hands on CPR training to club members. This workshop was necessary for the members traveling to Rwanda in February. Each member had the opportunity to learn about action plans during emergencies they may encounter. We also learned how to work as a team to minimize errors during medical emergencies. This was one of the most inspiring workshops we attended, because we learned how to use these basic skills in a real-life emergency. Most of our members are now CPR certified.

We also received hands on training on the AED defibrillator and its benefits in a chronic medical emergency. This was beneficial because during a medical emergency a team should be able carry out a plan under stressful situations.

WATER TESTING AND GPS TRACKING WORKSHOP



In January 2019, we had our first Water Testing Workshop. Dr. Miguel Bustamante, our mentor for this project, gave us hands on training in testing water quality for the Rwanda Water Project. This experience helped us realize the importance of clean sanitized water. This is central as our goal is to provide safe clean drinking water to those in need. The team learned different techniques to ensure the purity of water. This hands on training helped us conduct tests in various bodies of water in Kibingo, Rwanda.

In addition to water testing, we also learned how to operate a GPS tracking device. This is an important skill for this project. Kibingo, Rwanda is mostly rugged terrain and is difficult to navigate, so knowing how to navigate the rugged terrain with a GPS tracking device is imperative.

NYC AREA MINI CONFERENCE

In February 2019, Engineers Without Borders participated in the second annual Engineers Without Borders NYC area Mini Conference at Columbia University. This day was 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. These workshops ranged from Planning and Executing a Successful Fundraising Event, Project Management, Leadership, Technical aspects, to Real Life scenarios and Traveling tips. Our members established connections with other chapters which may assist us with other resources required for this project.

RWANDA POTABLE WATER PROJECT, ASSESSMENT TRIP

The club's major achievement this year was the opportunity to adopt our very first Project in Kibingo, Rwanda. This project defines what EWB stands for, "Making a better and sustainable future for people." Our team will visit Rwanda along with our Faculty Advisor Dr. Bustamante and our Project mentor Patrick. Here we will inspect the quality of water and develop an implementation plan for a sustainable system that will be highly reliable for the residents of the area.

In February 2019, we embarked on their very first assessment trip to Rwanda along with Dr. Bustamante our faculty advisor and Patrick our project mentor. This experience was highly educational and our mission was successful. Our team immediately got to work and involved themselves in the community. Our first step was to understand the issues faced by the local community; this gave us an idea of how important and essential it is to help them. The skills we

learned from the water testing workshop were put to the test as we started testing different local bodies of water.

This would not have been possible without the help of the local people in 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. Engineering and Technology department is making significant progress toward implementation of those goals. Below are current initiatives the College is implementing to attain those 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.

  In summer 2018, based on new recommendations by the PD and on approval of the project officer, the College's current Title III grant (P031C160021) provided additional funding to support and further expand the SI program in order to improve student learning outcomes and prepare students for the core courses within all engineering and engineering technology programs. Under the College's Title III grant, Vaughn added sixteen SIs for in fall 2018 to assist and improve students' performance through fundamental engineering and engineering technology related courses. Also, Vaughn's two writing specialists, in Teaching and Learning Center (TLC) assisted many students with their capstone degree projects, technical writing and presentation. 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, annual conference of the Society of Women Engineers, Latin American and Caribbean Consortium of Engineering Institutions, Society of Hispanic Professional Engineers (SHPE), and International American Helicopter Society (**attaining goals 1 & 2**).
- In summer 2018, based on new recommendations by the PD and on approval of the project officer, the College's current Title III grant (P031C160021) provided additional funding support to further expand students 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 SAE clubs activities and competitions. As a result of this program, Vaughn's UAV club participated as a finalist in 2018 American Helicopter Society (AHS) Micro Air Vehicle competition and finished first in both autonomous and remote control categories of this challenging competition. Vaughn's Robotics club finished first in 2017 VEX U International Mexican Robotics competition and second in 2018 Mexican International competition. Also, this is the second year in a row that a Vaughn student wins the Nissan Design Challenge of Society of Hispanic Professional Engineers (SHPE) Conference. In 2017, Darwing Espinal's design idea "An Active Suspension System" won third place, and in 2018 **Angel Calderon's** design idea "**Adaptive Air Intake** – Enhancing efficiency of existing engines and reducing carbon footprint" won first place in this challenging competition (**attaining goals 1 & 2**) .
- Students in Robotics, UAV, SWE, EWB, SAE, NSBE, and SHPE organized and hosted many STEM related workshops for middle school and high school students. They also provided assistance to many high schools to host their regional robotics and drone competitions. Vaughn's UAV team continuously assisted the Cradle of Aviation Museum in developing and hosting drone games and competitions for high school students. The

Department Chair and faculty attended some of these events to increase awareness about Vaughn's engineering programs (**attaining goal 3-outreach**).

- **Program Articulations:**
  - In February, the Project Director and STEM Pathway Liaison established a program articulation with Robert F. Kennedy Community High School. As part of this agreement, Robert F. Kennedy's junior and senior level students can enroll for Introduction to Robotics, **MCE101,** 1 credit (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. As of February 16, seventeen RFK students enrolled for this course at Vaughn. The expected date of completion for the course is June 1st.
  - In December, the Project Director and STEM Pathway Liaison met with RFK and modified the current program articulation to include CDE117 (Engineering Graphic, 2 credits, four contact hours). As part of this agreement, RFK's junior and senior level students can enroll for both **MCE101 (**Introduction to Robotics, 1 credit, three contact hours) and CDE117 (Engineering Graphic, 2 credits, four 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. As of February 16, seventeen RFK students enrolled for this course at Vaughn. The expected date of completion for the course is June 1st.
  - In November PD and STEM Pathway Liaison met with Hillcrest High School Work Based Learning Coordinator and they agreed to meet in early 2019 to develop a program articulation allowing Hillcrest's junior and senior level students to take college level technical courses at Vaughn.

- **Advanced Manufacturing Training and Workshops:**
  1. On May 14, 2018 Dr. Budhoo, composite prototype curriculum designer, attended a five day training on advanced composite manufacturing II in Reno, Nevada. The purpose of this training was to enhance his knowledge and skills in composite manufacturing so he can teach our student in composite certificate program with technology that is current in today's manufacturing industries.
  2. From June 11-15, 2018 Professor Manuel Jesus, 3D/CNC curriculum Designer, attended the Atlantic Design and Manufacturing Conference that was held in NYC at the Javits Center in Manhattan. The show was a great opportunity to engage with companies that develop all sorts of manufacturing equipment. Prof. Jesus attended the show to explore new developments in 3D metal printing and found some interesting advancements.
  3. From November 12–14, 2018, PD organized a three-day (9 am – 4 pm) power electronics & systems training with U.S. Didactic and Lucas-Nulle at Vaughn's Smart Grid Power Systems Laboratory. This training provided four Vaughn engineering faculty members with the hands-on laboratory skills for work with electrical machines, power electronics, motor drives circuits & controllers. This state-of-the-art laboratory was established in fall 2015 with funding support from the US Department of Education (Title III HSI-STEM) grant. This lab complements lecture courses in Electromagnetism (ELE323), Electric Machines

(ELE325), Power Electronics (ELE451), and Introduction to Power Systems (ELE452).

4. On October 2, Igor Brekman organized a training workshop "**How to run the HAAS VF2 SS CNC machine**" for Vaughn faculty. This demonstration centered on the process of preparing files to milling using MasterCam. CAM programs were discussed in general. G-Code edits were discussed in brief, however the importance of using CAM programming software for 3D parts instead of impractical hand-written G-Code programs was explored in detail. Brekman was able to POST the CAM file to a USB drive and initialize the program on the HASS.
5. On Friday October 5th, the PD arranged a day training workshop "How to StepCraft CNC Desk top machine" for students leaders in the UAV and SAE clubs. Students were treated to a demonstration of the StepCraft 840 Desktop CNC machine. This device differs greatly from the industrial HAAS range of CNC machines as its design intent is focused around quick and easy implementation of CNC tasks. The work area is ideal for UAV, Robotics, and SAE projects and many of the parts required consist of 2D milling on composite plates.
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 process of UAS and the automation certificate program.

These 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 practical hands-on STEM manufacturing training that is current with today's industry demands.

- **Stackable Certificate Programs:** In fall 2018, the grant management team was able to complete the following manufacturing certificate programs.
    1. **CNC Subtractive Manufacturing Certificate Program –** In early December, the Project Director with the assistance of the Grants Manager completed an application for a CNC Subtractive Manufacturing Certificate program which was submitted to the Academic Vice President for his review and submission to the NY State Department of Education. This certificate program has a total of 15 credits and will cover CNC manufacturing equipment and systems used in the subtractive manufacturing field. Students will gain practical experience developing CAM programs with G-Code, Mastercam, and CATIA for the Hass mill and Okuma Lathe CNC machines.
    2. **UAS Certificate Program:** In early December the PD had a meeting with the aeronautical curriculum designer regarding UAS certificate program development. This certificate program will include four to five courses related to UAS design, construction, application and regulation. We expect to complete and submit this certificate program to the NY State Department of Education in academic year 2019.

In 2017 academic**,** 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 purchase of supporting equipment.

- **BS in Advanced Manufacturing:** The Manufacturing Curriculum Committee is developing a new Advanced Manufacturing Engineering Technology program 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. Beside 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 advanced manufacturing process and design. To complete this program, students are required to take a total of 131 credits: 60 credits in liberal arts, math, and science courses; 30 credits in engineering science; 10 credits in computer-aided design and computer-aided manufacturing; 9 credits in composite design and manufacturing; 9 credits in CNC machining; 10 credits in UAS and automation; 3 credit manufacturing capstone project. The first draft of this program has been introduced to our Industry Advisory Council members during Vaughn's 2018 annual Technology Day Conference.
- **Laboratory Development:** The Engineering and Technology Department is in the process of establishing three new state-of-the-art facilities: the Composite Manufacturing Center, the CNC Machining center, and the UAS Center. Additionally, the department will provide enhancement of the currently established 3D Prototyping Innovation Center, mechanical testing laboratory, and PLC & Automation laboratory. In 2017-2018 academic year the following completed purchases of laboratory equipment:
    1. Instron material test system (Tensile tester - 5982 Model 5982 Materials Testing System), Price **$78,191**, Mechanical Testing lab.
    2. CNC Lathe Machine (Okuma GENOS L200E-MY-EX 500 (14.08)), Price **$102,900**, CNC Machining Center
    3. Coordinate Measuring Machine (CMM - Revolution "HB" 5.9.4 Shop Floor CMM (5-Axis)), Price **$79,900,** CNC Machining Center
    4. CNC Stepcraft 2/D 840 Desktop Systems, Price **$10,396.58**, CNC Machining Center
    5. 3 (model D45-01) Digilab 3D Printer, Price **$4,197**, 3D Prototyping Innovation Center
    6. ProJet MJP 2500 Plus 3D Printer, Price **$50,650**, 3D Prototyping Innovation Center
    7. 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 additive manufacturing, CNC machining, composite, and automation that are current with today's manufacturing industry standards.

Students' accomplishments and success: Below is a list of students' accomplishments and success that are a 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 events 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 eight ranking in Innovate division of the 2018 world championship out of 84 participating teams. Vaughn's team retained their standing as one of the top competitors (top eight teams) in the world championship by advancing to the quarter-final of playoff round of this intense competition for the fifth year in a row.
    - The Vaughn College Robotics team, one of the top competitors in 2018 VEX U Robotics world championship, was invited to participate in Mexico's VEX U Reeduca Robotics competition in Cancun, Mexico. The team finished second place overall in the competition and earned First place for the Robotics Skills (Programming and driving skills) champion category and is currently first in the world in the Skills category. For the past four years, Vaughn's robotics team members consistently demonstrate persistence and drive in order to attain their title as champions and top competitors in Mexico's VEX U Robotics competitions.
    - Vaughn College is planning to host two regional VEX Robotics Qualifying competitions on Friday February 8 for High Schools and Saturday February 9 for colleges.
    - On Saturday February 23, 2019, Vaughn College's Robotics team participated at the New Hampshire VEX U Robotics Regional Tournament. Vaughn's robotics team finished first and won first place in both "Robot Skills" and "Excellence" awards with qualification to participate in the 2019 VEX U world championship.
    - In spring 2019, Vaughn College 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 fifth annual state qualifier high school robotics competition on Saturday February 9, 2019. A total of 35-40 regional high schools from Queens, Brooklyn, Bronx, Nassau, and Suffolk countries are planning to attend the February VEX state qualifier at Vaughn College.
        - ✓ Vaughn Robotics team assisted Farmingdale High School in hosting their regional high school robotics competition on Sunday, Jan 7, 2018.
        - ✓ 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 2, 2019,.

- ✓ Vaughn Robotics team hosted Robotics workshops for High School students (Freeport, Bayside, Thomas Edison, ESBOCES Engineering) during Vaughn's Annual Manufacturing Day conference on Friday, Oct 19, 2018
- ✓ On Friday, November 16, 2018, Vaughn Robotics team hosed a STEM workshop for 27 Hillcrest high school students and their mentors at Vaughn College..
- ✓ Vaughn Robotics team hosted Robotics workshops for High School students during Vaughn's Annual International Drone Day On Saturday May 5, 2018.

2. Since 2016, the Vaughn College UAV team participated in Micro Air Vehicle completion of the American Helicopter Society (AHS) 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. The Vaughn's UAV team won the 2nd place award of 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.
   - **Unmanned Fixed-Wing Aircraft:** In 2018-2019, the UAV Club began preparing to compete in the Student Unmanned Aerial Systems (SUAS) competition hosted by the Association for Unmanned Vehicle Systems International (AUVSI). Due to the scope of this challenge, the UAV Club will begin development of unmanned fixed-wing aircraft capable of long-range flight while carrying large mission-critical payloads.
   - Outreach Activities:
     - ✓ Since 2016, Vaughn's UAV team assisted the **Cradle of Aviation** Museum with UAV workshops and competitions 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 along with 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.**

In addition to the above accomplishments, as a result of the HSI STEM grant many of Vaughn's students were enabled to participate in scholarly activities and student paper and poster sessions in regional, national and international conferences and competitions (ASEE, LACCEI, SWE, ASME, SHPE, and IEEE) and receive top ranking in those events. Also, the HSI STEM grant

provided necessary funding support for clubs such as SWE, EWB, SHPE, and NSBE to be involved 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 and student success and accomplishments.

List of 2018 Placement Activity

The following table provides graduates' 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 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, Pratt and Whiney, John Deere, Rolls-Royce, Volvo, Harris Corporation, Magellan Aerospace, Collins Aerospace, FAA, Safe Flight Instruments, 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**
Eric Grieco	Mechatronic Eng.	Precise LED Summer 2018	Trinova Inc., Sum 2019 Automation Engineer	
Utsav Shah	Mechatronic Eng	DJI Summer 2017	SOLVAY - June 2018 Automation & Robotics	
David Adegbesan	Mechatronic Eng		John Deere- Sum 2018	
Niki Taheri	Mechatronic Eng.	Con Edison – Sum 2017 Long Island Rail Road-2018	Volvo Motor, Summer 2019	
John Hernandez	Mechatronic Eng.	Festo Summer 2018		
Daniel Khodos	Mechatronic Eng.	SciMax Tech, Sum 2016 Rolls-Royce, Sum 2017	L&L Products-2018 Automation Engineer	
Jamal Sharifi	Mechatronic Eng.		Cox and Company, sum 2018	
Samantha Vitez	Mechatronic Eng.	NASA propulsion Lab – Summer 2018		
Richi Ramlal	Mechatronic Eng.	LIRR Sum 2018		
Oliver Khairallah	Mechatronic Eng.		NYU Neuro science laboratory engineer, Fall 2018	
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		
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		
Sagufta Kapadia	Mechatronic Eng.	Lockheed Martin, Sum 2019		
Juan Rodriguez	Mechatronic Eng.	Easy Aerial, Inc., Sum 2018 and 2019		
Jonahz Hernandez	ME	Rolls-Royce, Sum 2019		
Chamathke Perera	ME	Easy Aerial, Inc., Sum 2018 and 2019		
Aderet Pantierer	ME	Boeing, Summer 2019		
Shmuel Pantierer	ME	SciMax Technologies, Summer 2019		
Sayhat M. Karca	ME	Magellan Aerospace Sum 2017	Magellan Aerospace, Spring 2018	
Ariel Ferrera	ME	Stryker, Summer 2018&2019		
Frandi Cueva	ME	Toyota, Co-op 2019		
Mostafa Aboali	ME		Boeing-The wiring Integration Design – Fall 2018	
Muhammed Galib	ME	Easy Aerial, Inc., Sum 2018 and 2019		
Nicolas F Ceballos	ME	SciMax Technologies, Summer 2018	Lockheed Martin, Sikorsky Aircraft, Feb 2019	
Brandon Duran	ME	Hudson Technology – Summer 2017 & 2018		
Thomas J Dekenipp	MET		CPI-Aero, Spring 2019	
Mohammad Fahim Shahriar	MET	Con Edison-Sum 2018		
Jairo Chauca	MET	Harris Corporation, Sum 2018	Harris Corporation, Spring 2019	
Kirei Watson	MET		Collins Aerospace, Spring 2019	
James Bargfrede	MET		CPI Aero, Dec 2018	
Tristan Kho	MET		CPI Aero, Summer 2018	
Angel Calderon	MET	Nissan, Summer 2019		
Robert Escobar	MET		Turner, Summer 2019	
Yarelys Vazquez-Marquez	MET	Pratt & Whitney, 2019		
Alana Hasselman	MET		Cyient – August 2018	
Umar Khan	MET		CPI-Aero, Fall 2018	
Grace Davis	MET	Daimler Summer 2018 Eaton, Summer 2019		
Darwing E. Mota	MET	Exelon – Summer 2017 Gulfstream, Summer 2018	Raytheon, Summer 2019	
Adham Mostafa	MET		Cyient, Dec 2018.	
Andrew Sohn	EET		Air China	
Sixin Nie	EET		Panasonic Avionics	
Johnny Jiminez	EET		SafeFlight Instruments	
Mahendra Taramal	EET		OSHA - NYC	
Reynaldo Francis	EET		FAA Technical Operations - 2018	
Devendra Singh	EET		FAA Technical Operations - 2018	
Marvin Guzman	EET		FAA Technical Operations - 2018	
Lily Alexander	EET		FAA Air Traffic Control - 2018	

Design and Fabrication of Small-Scale Supersonic Wind Tunnel

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Abstract

This paper presents the design 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.

Introduction

Supersonic commercial air travel is on the rise. As a result, the study of aerodynamics is becoming more important in the understanding of the forces an object experiences as it moves through air. Since academic research in the field of supersonic technology is minimal, there is a need for more work in the aviation and aerospace field. Supersonic testing facilities are required to safely and efficiently observe structures as they undergo a velocity stream faster than the speed of sound. These large-scale testing facilities can be interpreted as small-scale subcomponents consisting of a compression configuration, mylar diaphragm, convergent-divergent nozzle, testing chamber, and a flow diffuser section. A supersonic testing apparatus will be advantageous for future generations of students in understanding the design and analysis of aerodynamic flow above Mach 1.

A. Background

Manufacturing a new aircraft is extremely expensive and requires extensive testing. In the 19th century there were forms of wind tunnels; however, they were not very effective. The environment they created was insufficient to accurately measure the experience of an aircraft. Despite the impracticality of these tunnels, the experiments advanced the geometry of airfoils and the understanding of lift forces. One of the most successful wind tunnels was a 30 by 60 foot machine manufactured by NACA in 1931. During WWII, supersonic flight was a main focus throughout the world and testing facilities were required to produce a safe aircraft. The Supersonic wind tunnel required an enormous amount of power which resulted in high pressure storage tanks as well as vacuums to create supersonic speeds. One of the smallest supersonic wind tunnels created contains a 2.543 in. by 2.5 in. testing chamber. Three categories of wind

tunnels are: indraft, blowdown, and pressure vacuum [1]. Indraft tunnels rely on a negative pressure at the exhaust with atmosphere conditions at the inlet. Blowndown tunnels consist of a high pressure at the inlet via chambers of compressed air and atmospheric conditions at the exhaust. The pressure vacuum tunnel is a combination of both indraft and blowdown, altering both inlet and outlet. This report focuses on a blowdown tunnel.

Supersonic Wind Tunnel Components

A. Compression Configuration

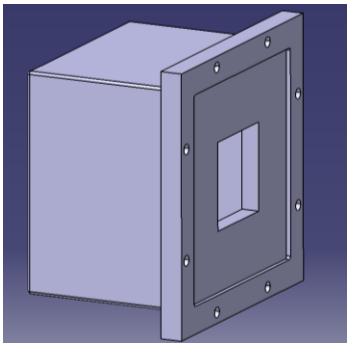


Fig. 1 Isometric view of Compression tank

When a significant amount of compressed air is stored, the difference in pressure required to reach sonic flow and above is achieved. The greater the difference in pressure, the higher the Mach flow. A preliminary design is an aluminum cube with a minimum wall thickness of .25 of an inch that can withstand a maximum of 100 psi. The cube will have a .5-inch-thick flange to connect to the convergent-divergent nozzle and testing chamber. A unique aspect of this compression system is a faulty diaphragm that collapses at a specified pressure. The diaphragm is preferable to a ball valve since the flow exiting the compression system is almost instantaneous, rather than a gradual release. This is vital since flow must be distributed across the entire face of the nozzle to maintain low turbulence in the flow upstream of the testing area. A safety valve is used to release flow if pressure surpasses the desired value. A pressure gage will be fitted to monitor the rising pressure within the chamber. A further consideration is that condensation may accumulate in the chamber as the air is being compressed. Air flowing to the tank needs to be dehumidified to prevent icing. Research and calculation conducted concludes the desired pressure of the chamber to be 70 psi in order to achieve a Mach flow of 1.6. The compression configuration is an original design and necessary to prevent turbulent flow. Eq. 1 represents the pressure ratio of the ambient atmospheric temperature to the pressure the compression configuration will hold in order to achieve Mach flow [2].

$$\frac{P_0}{P^*} = \left(\frac{T_0}{T^*}\right)^{\frac{\gamma}{\gamma-1}} \qquad (1)$$

B. Mylar Diaphragm

Rupturing a diaphragm between the compression section and convergent nozzle is integral as it allows for a uniform flow. Uniform flow allows the fluid in which each particle moves along its line of flow to retain constant speed. The diaphragm will have a thickness of 0.1 of an inch, with an X shaped serration of 0.03125 of an inch deep. To ensure the diaphragm does not produce a

loss of pressure it must be manufactured with the same thickness as the groove on the compression chamber. The compression configuration is fastened to the nozzle with material capable of withstanding and securing low to high pressure loads. Once failure occurs on the diaphragm it will rupture, creating a uniform flow that is instantaneous. This is done to prevent turbulent vortices. If the diaphragm is not utilized, the air from the compressor will gradually flow into the nozzle preventing the increase in speed. By using a mylar diaphragm that will rupture, a sudden change in pressure creating the flow required for supersonic speed can be accomplished.

C. Convergent-Divergent Nozzle Geometry

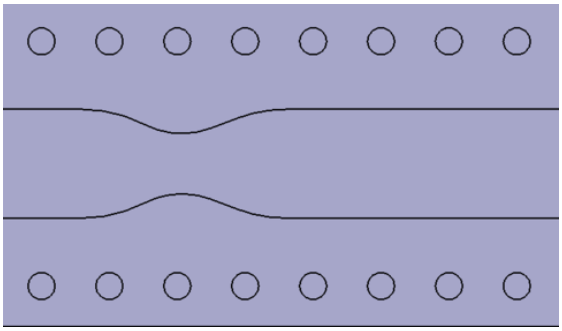


Fig. 2 C-D Nozzle Geometry

A convergent-divergent nozzle is a specially shaped tube designed to speed up the flow of the air and thrust it through the testing chamber. Both sections of the nozzle will be fixed, making the design of the nozzle vital with no room for error. The convergent section will increase the velocity of the compressed air to a sonic flow.

$$\left(\frac{A}{A^*}\right)^2 = \frac{1}{M^2}\left[\frac{2}{\gamma+1}\left(1 + \frac{\gamma-1}{2}M^2\right)\right]^{\frac{\gamma+1}{\gamma-1}} \qquad (2)$$

The calculation required to gain the ratio desired to speed up the flow to a desired speed can be seen in Eq.2 [2]. The ratio seemed minimal in an effort to achieve a high Mach flow, and after simulation and consideration of friction due to boundary layer flow, the area ratio was increased by 25% to achieve better flow. Considering the flow to be sonic at the throat, the divergent duct increases the speed to a supersonic flow. If the flow is subsonic at the throat the velocity decreases in the divergent duct section. These affects can be seen using Eq.1 which relates the area *(dA)* and velocity *(du)*. A large difference in pressure from the compression system and testing chamber is used to achieve the sonic flow at the throat. Designing the nozzle can be tedious as any sharp corners or angles can cause disturbances in the flow and diffuse the velocity too soon. From research conducted, with the desired Mach flow of 1.6, the area ratio between the throat and testing chamber must be 1.439.

$$\frac{dA}{\mathrm{A}} = (M2 - 1)\frac{du}{\mathrm{u}} \qquad (3)$$

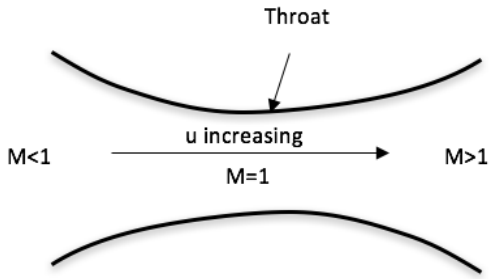


Fig. 3 Convergent-Divergent Nozzle Geometry

D. Testing Chamber

This section is where the flow has to have the highest Mach value. Design intent is to have an oblique shockwave occur on the object being investigated, so that the wave reflections produced will be at an angle that doesn't disturb the air flow. If a slight disturbance occurs at some point in the air, information is transmitted to other points by sound waves which propagate in all directions away from the source of the disturbance. The gas molecules which impact the body surface experience a change in momentum. In turn, this change is transmitted to neighboring molecules by random molecular collisions [2]. Oblique, shock, and compression waves are prevalent in two- and three- dimensional supersonic flows. These waves are inherently two-dimensional in nature. The angle that the Mach wave makes with respect to the direction of motion of the material is defined as the Mach angle μ.

$$\frac{T_0}{T^*} = 1 + \frac{\gamma-1}{2}(M)^2 \qquad (4)$$

The maximum extreme temperature being experienced in the chamber will be -125.15 degrees Celsius as seen in Eq. 4; this fact is important due to the critical points of the air [2]. This calculation was based off of a room temperature of 70 degrees Fahrenheit (21.1 degrees Celsius). Nitrogen makes up 78.09 % of the air, Oxygen holds 20.95 %; with this fact in mind we must take into consideration the critical points of these gasses. Nitrogen becomes a liquid at -196 degrees Celsius and Oxygen turns to liquid at -183 degrees Celsius [4]. The air being compressed will not reach a critical point to become liquefied. This point is integral, since the air will not be detrimental to the system at our required compression temperature and Mach flow temperature.

E. Flow Diffuser Section

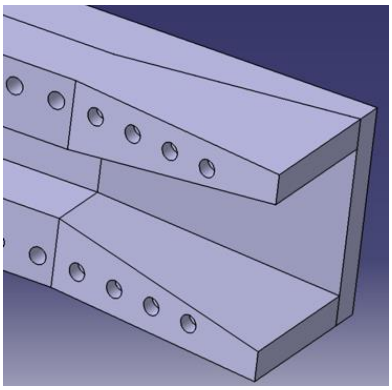


Fig. 4 Diffuser geometry

A diffuser is a device whose role is to slow the incoming air to a very low velocity and achieve as small a loss in total pressure as possible. Flow enters the diffuser at supersonic speeds, and due to its isentropic nature, the pressure is constant throughout the entire diffuser. It is extremely difficult to slow a supersonic flow without generating shock waves in the process. In real life, the flow is viscous; there will be an entropy increase within the boundary layers on the walls of the diffuser. This boundary layer flow creates separation that narrows the area before entering the diffuser, acting like a supersonic diffuser. The behavior of the flow determines whether the geometry can be depicted as a nozzle or a diffuser.

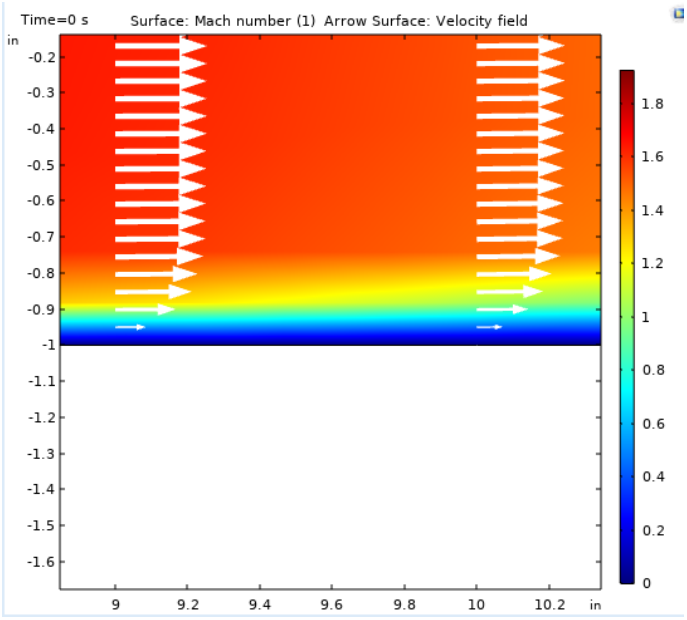


Fig. 5 Boundary Layer Flow

For these reasons, the flow must be slowed by a reflected compression shock. Once exiting the testing chamber, the flow will experience a rapid convex angle of 8.5 degrees. This angle is integral in order to allow the compression shock wave to experience the incoming flow normal to the testing chamber. The flow at the wall must be tangent to the wall; hence, the streamline at the wall is also deflected downward through the angle θ. The bulk of the gas is above the wall, and the streamlines are turned downward, away from the main bulk of the flow. Whenever a supersonic flow is turned away from itself, a compression wave will occur. The original horizontal streamlines ahead of the compression wave are deflected smoothly and continuously through the compression fan such that the streamlines behind the wave are parallel to each other and inclined downward at the deflection angle θ [2].

$$\theta = \upsilon(M2) + \upsilon(M2) \qquad (5)$$

Eq.5 above represents the deflection angle of the geometry, where υ is the Prandtl-Meyer angle based on the input Mach value before or after the wave [2]. Across the compression wave, the Mach number increases, and the pressure, temperature, and density decrease. Hence, a

compression wave is the direct antithesis of a shock wave. Due to the wide angle being used, the flow separates and begins to slow down.

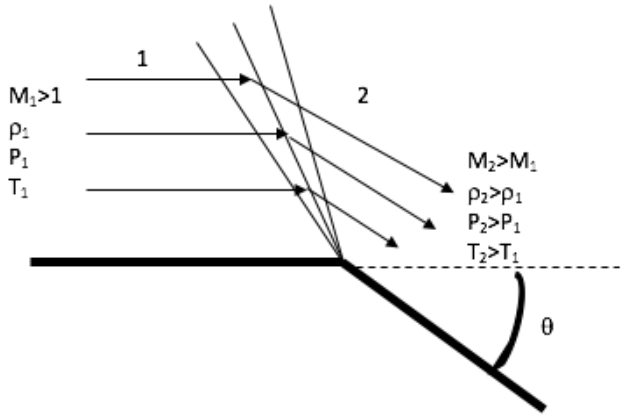


Fig. 6 Visual of Compression wave

Initial Design

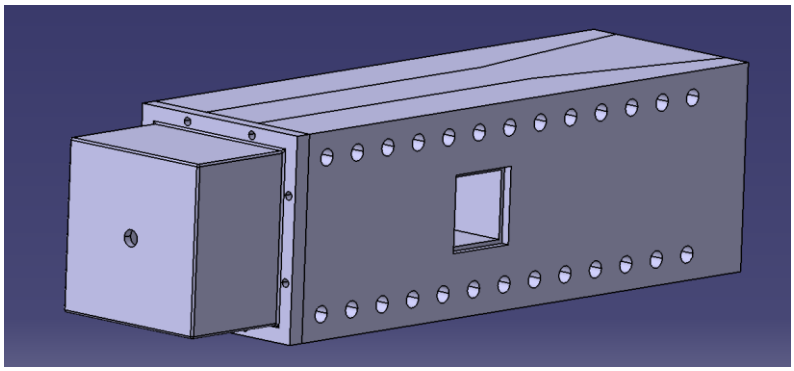


Fig. 7 CAD model of Initial Design

Using CATIA V5, three parts were created and assembled to construct the supersonic wind tunnel. The compression chamber consists of two 0.5-inch holes, one receives air from the compressor and the other has a pressure gage that acts as a relieve valve. The convergent-divergent nozzle, testing chamber, and diffuser were made as a solid piece. To ensure symmetry, the upper section of the wind tunnel was mirrored to create the lower section. Plexiglass was used to enclose a viewing window of the testing chamber, allowing the user to view inside the testing chamber. The geometry of the tunnel was fastened together using bolts and gaskets to prevent the loss of pressure. The assembly work bench was utilized to compile the three sections. Figure 7 demonstrates the potential outcome of the wind tunnel. A mylar rupture diaphragm is not seen in the figure.

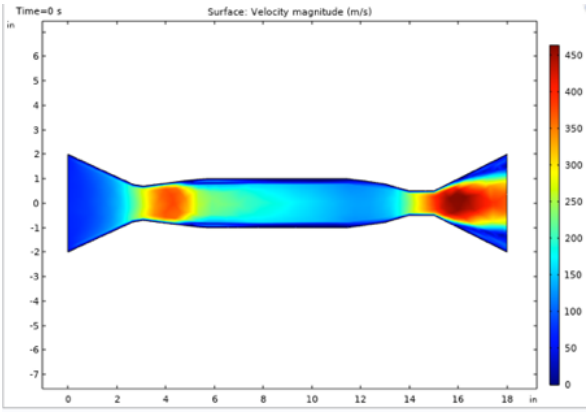
A. Analytical Calculation

Verification of results through analytical calculation and comparison with simulated results is a vital step in the fabrication process. A calculation of the ratio of inlet to exit area of the CD Nozzle is done by using Eq. 2; this process determines the overall geometry required to speed the

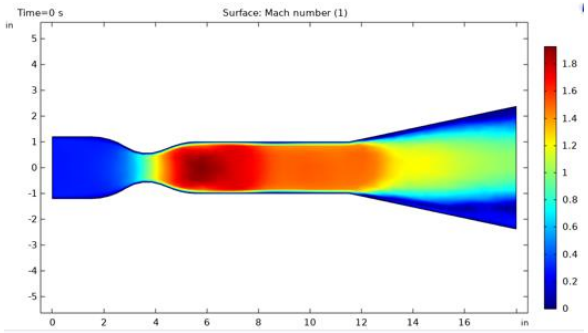
flow above Mach speeds. A* is the area of the throat in the C-D Nozzle, γ is the Specific heat ratio which is a universal gas constant in air. M represents the Mach number. The initial calculation did not produce the results desired. After consideration of skin friction, the ratio area was increased by 25% in order to speed up the flow, which resulted in a smaller throat area. Knowing the amount of pressure required to produce the desired Mach flow is one of the first steps before rendering any kind of model or simulation. The amount of pressure can be calculated using Eq.1 which represents the pressure ratio of the ambient atmospheric temperature to the pressure the compression configuration will hold in order to achieve Mach flow. These values are dependent on the temperature and universal gas constant of Gamma. Our initial design pressure intended 100 psi to achieve of Mach flow of 1.8. After not achieving the desired diffusion, the pressure was changed to 70 psi and achieved a Mach flow of 1.6, while still allowing for proper diffusion. When the flow moves at such a high rate, the temperature begins to drop, which establishes the capability of certain elements reaching critical points. Eq. 4 was used to calculate the temperature of the flow at its highest Mach value in order to ensure safety. These values are dependent on Mach value and the universal gas constant of Gamma.

B. Simulation

In order to achieve the correct geometry necessary to achieve Mach flow and above, a simulation is required to verify our analytical calculations. The utilization of Computational Fluid Dynamic analysis software such as COMSOL Multiphysics is vital for determining the Mach flow received within the C-D Nozzle, Testing Chamber, in order to observe how the flow will diffuse [3]. The software package includes a form of CAD environment interface that allows the user to directly import a form of 3D geometry created with CAD. With this in mind, the negative space of the wind tunnel was required to conduct testing and geometry manipulation, in order to physically visualize the motion of the flow, and its characteristics. A boolean and partition was conducted to subtract the remaining geometry of the wind tunnel, so the user is left with the negative space alone. After the import of the CAD model to the design modeler, a mesh of elements was applied in order to gain more accurate results for specific areas of the geometry. The inlet, outlet, and wall boundary conditions were then created in order to specify certain characteristics of the flow. Using the negative space of the wind tunnel a COMSOL simulation can be created based on a change in Pressure. The inlet was set to 70 psi while the exhaust is set to 1 atm. Supersonic flow was achieved past the throat of the C-D Nozzle, due to the fact that the conditions were not sonic at the throat, supersonic flow was not continuous into the testing chamber. An analysis on the size of the inlet was executed, producing the same result in the testing chamber; however, the narrower area had a greater incoming speed than that of the larger inlet area. Using oblique shockwaves to reduce the velocity of the air results in a narrow exhaust causing the air speed to increase without a decrease at the exhaust. The inaccurate result of the oblique shockwave stemmed from the use of compression waves in order to better diffuse the flow. When negative results in the diffusion were observed, the inlet pressure was decreased, due to a direct relationship between the pressure and velocity, which resulted in a more effective diffusion. COMSOL solutions were compared using a mesh analysis ranging from a Fine mesh with 78,713 elements to a finer mesh with 1,613,751 elements. Each analysis provided more accurate results maintaining the same successful outcome.



(Before)



(After)

Fig. 8 COMSOL simulation (before & after)

Discussion and Results

Initially, a geometry selection was chosen based solely off analytical calculation, without consideration of friction due to boundary layer flow, the inlet size of the compression chamber attached to the C-D nozzle, length of the testing chamber and diffuser, and the angle and shape of the diffuser. All of these traits have a direct relation to the performance of the flow and its diffusion. The selection of inlet pressure was too large to effectively diffuse the flow within a short range, resulting in a pressure of less magnitude. The curvature of the C-D nozzle originally contained sharp corners filleted edges. This geometry failed to produce a smooth transition of flow to the testing chamber. With this in mind, the geometry contours were redesigned to obtain less turbulent characteristics and better streamlines. The direction of the diffuser in the Y and Z direction created better results, considering an angle of 19 degrees in all directions. After extensive analysis and simulation, a final geometry was chosen. The utilization of a compression wave rather than an oblique shockwave was a key factor in producing diffusion results. Utilizing the geometry that produced the highest flow in the chamber with the best diffusion was a building block to the final product. With an alteration in the incoming pressure, we began to obtain the greatest results. The highest Mach value of 1.929 was obtained in the testing chamber and a diffusion result of subsonic at 0.8 in the exhaust. To ensure our results were accurate a mesh conversion study was performed, and a comparison of the results were obtained. With a finer mesh quality and smaller tetrahedral elements, results were altered. Higher Mach values

were obtained in the chamber with even lower flow temperature than anticipated, while still receiving subsonic flow in the exhaust. The flow becomes steady with no alteration due to time at less than .005 of a second. The fine mesh produced a Mach value of 1.927 at the testing chamber and 0.81 at the exhaust. Meanwhile the finer mesh produced a Mach value of 1.929 at the testing section and 0.8 at the exhaust. The difference in values reflects the number of elements used in each analysis yielding more accurate results.

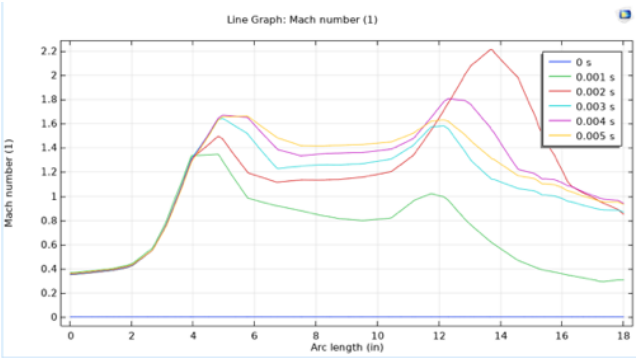


Fig. 9 Mach Number vs. Length

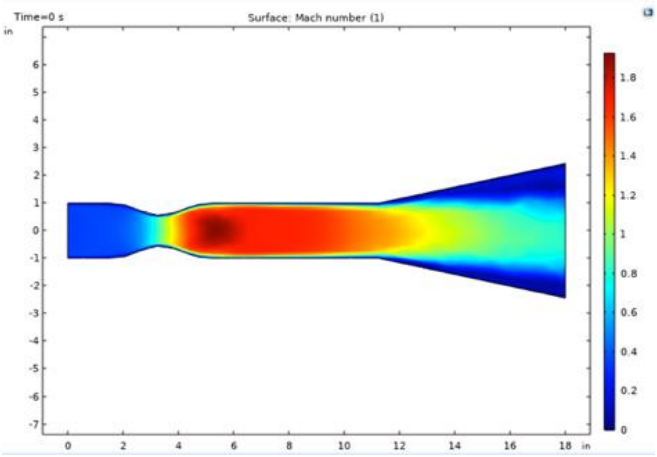


Fig. 10 Final Simulation

Conclusion

A final geometry configuration is designed and selected for the fabrication of the Small Scale Super Sonic Wind Tunnel. The analysis of the Super Sonic Wind tunnel is conducted using COMSOL Multiphysics, along with analytical calculation for the geometry configuration, and a mesh conversion study to produce more accurate results. An inlet pressure of 70 psi produces supersonic flow at speeds of Mach 1.929 in the testing chamber while diffusing the flow to subsonic at Mach 0.8 in the exhaust. Flow loads are identified to verify loading conditions. Manufacturing and fabrication is done to produce a model fit for testing and analysis of aerospace structures and components.

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Affordable Strain Gauge Indicator (ASGI)

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ABSTRACT

One of the primary constants used to describe a material is known as Young's elastic modulus. This material property describes how much force it requires to deform (apply strain) to a material. Strain gauges are sensors used in conjunction with an indicator to measure deformation on an object, information that is then used in product testing and in obtaining valuable constants like the elastic modulus. Traditional strain indicators, however, are expensive and outdated making it difficult to conduct strain testing. This capstone project proposes the Affordable Strain Gauge Indicator (ASGI) with a modern data acquisition system, as well as, an easy-to-use interface. It will provide for cloud storage using the user's personal Google Drive account, USB flash memory storage, and an LCD touch screen with an intuitive graphic interface.

1. INTRODUCTION

Recent advancements in manufacturing, namely 3D printing and composite materials, have become very popular among professionals who manufacture new products, students learning about these advancements, and hobbyists making 3D objects.. In 3D printing, products are created with different structures of materials—inducing a change in the material's properties—depending on the type of 3D printer and variety of settings used to print. Since these material properties are always changing, there is a need for an instrument like the affordable strain gauge indicator that obtains these constants accurately, and is also accessible to the general public.

The objective of this project is to create a modern, affordable and accurate strain gauge indicator that is easy-to-use. The strain gauge indicator uses a microcontroller aiding for USB flash memory interfacing and Wi-fi connection to store data on the user's personal Google Drive account and is equipped with a touchscreen for intuitive user interface. This strain gauge indicator is also light-weight and battery-operated for portability.

2. BACKGROUND RESEARCH

Strain, represented by ε, is a term used to measure the deformation of an object that is subjected to a force [1]. Strain measurements allow the user to calculate the properties of a material, and it can provide an idea of how a material will behave. To measure strain, a gauge (Fig.1) [2] is

glued to the specimen being tested. As the specimen deforms the gauge deforms causing the electrical resistance on the gauge to change. The Affordable Strain Gauge Indicator (ASGI) is based on the most popular strain gauge measuring instrument on the market, the P3 Strain Indicator and Recorder (Fig. 2) [3]. The P3 is a portable, robust piece of machinery suitable for use in harsh environments; it has the capability of accepting four strain gauge inputs simultaneously and providing live data feed. However, the latest revision of the P3—released on 2011—uses an SD card, a product that is seldom used, and is equipped with a monochrome screen and physical buttons. The ASGI solves these problems with a modern touch-screen interface, the capability to store data on a flash drive, as well as the ability to seamlessly transfer data to the user's Google Drive account.

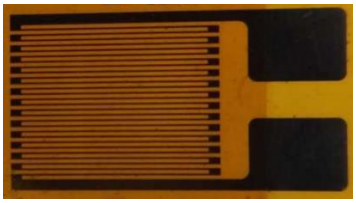

Figure 1. Metallic Foil Strain Gauge

Figure 2. Model P3 Strain Indicator and Recorder

Cloud storage [4] is a service in which data is stored on remote servers accessed from the internet. This service was popularized in the mid-2000s from products like Dropbox and Pinterest. Today companies like Google and Microsoft provide free cloud storage service as part of their email account service.

In 2017, a Cornell graduate used strain gauges to make a dynamometer measure power and torque on a rotating shaft; the strain gauge sends a signal that is transmitted and converted using an analog digital converter (ADC), and the data is then sent using Bluetooth. Based on our research, the dynamometer instrument is the only product measuring strain that wirelessly transmits data.

3. ENGINEERING REQUIREMENTS

The ASGI must be able of converting the strain gauge's analog signal to a digital value. The digital values can be displayed in real time on the ASGI's display, saved on its internal storage, transferred to a USB flash memory, or uploaded to the user's personal cloud storage. An analog to digital converter (ADC) chip that meets the strain measurement requirements (Table 1) was chosen to obtain data from the strain gauges. An 8.9 cm LCD touch screen was tested; however, it proved to be too small to accommodate an on-screen keyboard while signing into the user's Google account. A 17.8 cm touch screen provides enough real estate to ensure a comfortable user experience. A Nickel–metal hydride (NiMH) battery is used to supply the ASGI for up to 8 hours of continuous usage.

Table 1. List of Components and Constraints

General characteristics	
Size (L x B x H)	25.4 cm x 15.2 cm x 10.2 cm
Weight	2 kg
Microcontroller	Raspberry Pi (RPi) Model 3 B v1.2
Operating System	Linux kernel
Specifications for strain measurement	
Accuracy	1με
Sampling Rate	20 SPS
Strain gauge signal digitalization	TI ADS122C04 ADC (Sec. 4.2)
Specifications for data storage	
Internet storage	16 GB Micro SD card (containing Linux kernel)
Internal interfacing	BCM43438 wireless LAN; 100 Base Ethernet
USB flash memory interfacing	USB 2
Cloud storage service	Google Drive
Specifications for touch screen	
Type	LCD
Size	17.8 cm
Resolution	800x480
Specifications for battery	
Voltage	7.2V
Capacity	3000mAh
Type	NiMH (rechargeable)
Duration	up to 8 hours of continuous use
Voltage reading	Arduino Uno

4. SYSTEM DESIGN

4.1 Strain Gauge Value Measurement

To take a strain gauge's input the ASGI uses a circuit called the Wheatstone Bridge Circuit (Fig. 3), which consists of two voltage divider circuits in parallel. When all the resistors of the bridge

circuit are of the same value, the output voltage (V_0) is zero. Replacing one of the resistors with a strain gauge that has the same base resistance ($R_G = R_1 = R_2 = R_3$) as the other resistors makes the output voltage proportional to the strain measured by the gauge. This configuration is known as the quarter bridge circuit, because only one resistor is replaced by a strain gauge.

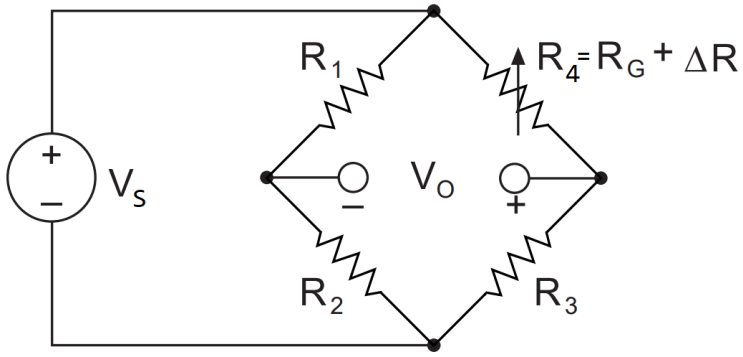

Figure 3. Wheatstone Bridge Circuit Configuration

The relationship between the output voltage of a bridge circuit and the strain (ε) measured by the strain gauge can be determined as follows:
Bridge circuit output voltage (Fig. 3):

$$V_0 = \left[\frac{R_3}{R_3+R_4} - \frac{R_2}{R_1+R_2}\right] V_S \quad (1)$$

The resistance of a strain gauge is given by its initial resistance (R) plus the change in resistance (ΔR):

$$R_4 = R + \Delta R \quad (2)$$

Gauge factor equation:

$$G_f = \frac{\Delta R}{R\varepsilon} \quad (3)$$

Considering that in eqs (1) and (2) $R_1 = R_2 = R_3 = R$, eqs (2) and (3) are merged with eq (1) to form:

$$\frac{V_0}{V_S} = -\frac{G_f \varepsilon}{4}\left(\frac{1}{1+G_f\frac{\varepsilon}{2}}\right) \quad (4)$$

$$\varepsilon = -\frac{4V_0}{G_f(V_S+2V_0)} \quad (5)$$

4.2 ADC Selection

The analog to digital converter (ADC) chip used for this project must meet the following constraints: minimum strain value measured (accuracy) must be $\varepsilon_{min} = 1\mu\varepsilon = 10^{-6}\varepsilon$, minimum gauge factor is $G_f = 2.0$, using a bridge circuit input voltage—ADC reference voltage—of $V_S = 5.0\,V$.

Minimum voltage is calculated by solving Equation (4) for V_0:

$$V_0 = V_{min} = -V_S \frac{G_f \varepsilon}{4} \left(\frac{1}{1 + G_f \frac{\varepsilon}{2}} \right) = - \frac{(2)(10^{-6})(5)}{4} \left(\frac{1}{1 + 2\frac{10^{-6}}{2}} \right) = -2.5 \times 10^{-6} V \quad (6)$$

Number of lowest significant bits (LSB) needed, if each LSB equals to the minimum voltage to be measured (6):

$$\# \, LSBs = \frac{V_S}{|V_{min}|} = \frac{5.0V}{2.5 \times 10^{-6} V} = 2.0 \times 10^6 \quad (7)$$

Estimate the number of bits needed to represent the desired number of LSBs (7):

$$\log_2 (2.0 \times 10^6) = 20.93 \quad (8)$$

From the estimate (8) it is concluded that the ASGI needs, at least, a 21-bit (20-bit data, 1-bit sign) ADC converter to have an accuracy of 1με. To ensure precise results, the maximum peak-to-peak noise must be less than half of the minimum voltage eq (6):

$$V_{pp} < \frac{|V_{min}|}{2} = 1.25 \times 10^6 V \quad (9)$$

The ADS122C04 from Texas Instruments meets all the project's requirements. It is a 24-bit ADC with peak-to-peak noise of 0.46×10^{-6} volts.

4.3 I2C Communication

The Texas Instruments ADS122C04 uses I2C (also known as I^2C) serial communication to transfer and receive data from a microcontroller (Raspberry Pi). In this manner, the ADC communicates the digital equivalent of the strain gauge's analog value in 2's complement form. I2C utilizes two wires: one for data, the other for the clock—determining the data transfer rate. The ground and high voltage for serial communication are provided by the RPi. To handle I2C communication the Raspberry Pi uses the 'smbus' library which provides the necessary dependencies for I2C communication using the Python programming language.

4.4 Graphic User Interface (GUI)

The 'Qt' framework was used to develop a GUI using Python. Qt provides basic widgets—among them text boxes, buttons, labels, etc.—for inputs and outputs used on modern computer programs and smart phone applications. This framework is also cross-platform, meaning that a GUI designed and test on Windows OS can be transferred to a Linux OS making the process of GUI development easier for programmers. The GUI illustrated by Figure 4 was designed on Windows using the integrated development environment 'designer' provided by Qt, then transferred to the Raspberry Pi running on a Linux kernel.

Figure 4. Python GUI

The ASGI's interface has two main functions: data recording, and upload to cloud—these are then subdivided into several functionalities which are distributed on the GUI's buttons. A flowchart description of the ASGI functionality is illustrated by Figure 5.

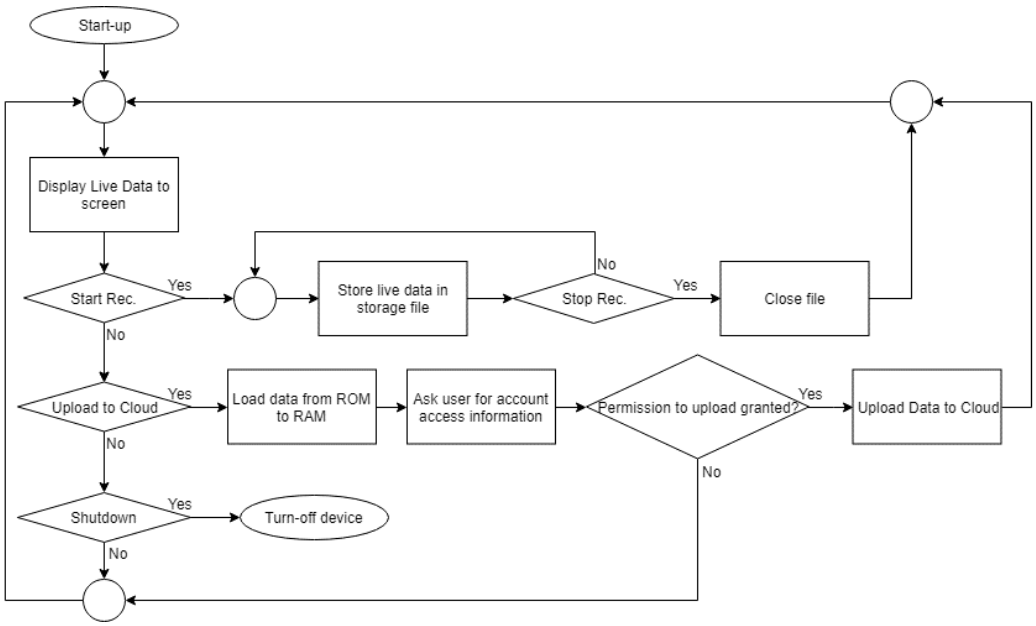

Figure 5. ASGI's GUI Usage Flow Chart

After starting up, the ASGI constantly checks if either one of the buttons "Start Rec.," "Upload to Cloud," or "Shutdown" are pressed. If the "Shutdown" button is pressed, the program terminates and shutsdown the device. As soon as the device turns on, it starts to display live data. The data will be recorded in the local drive if the "Rec. Data" button is pressed. To stop recording data the user must press the "Stop Rec" button. Pressing the "Upload to Cloud" button starts the uploading routine: first it loads the data stored on the local drive into memory, afterwards a pop-up asks for the user's Google account information and permission for the ASGI to upload data. The ASGI will not be able to upload data if permission is not granted; if permission is granted the data will be up successfully uploaded. In the GUI (Fig. 4), the

"Balance" button is used to set the initial reading to zero correcting any undesired drift of the values. The "Transfer to USB" button is unavailable until a USB flash memory is detected. When this button is pressed, it transfers the recorded data as a '.csv' with a time stamp.

4.5 Cloud Storage

To interface with Google Services the company provides a set of tools called Google APIs (Application Programmable Interfaces) [5], which can be implemented using the Python programming language. Google protects its users by enforcing a permission system in which applications must ask for the user's permission to access and modify their personal data. The ASGI uploads stored data to the user's Google account by creating a Google Sheets file. Once the 'Upload to Cloud' button is pressed the user is prompted to enter their account information. After signing in, it asks the user for permission to create and access spreadsheets files in Google Drive (Fig. 6). Developers must create a set of 'credentials,' provided by Google, and add 'scopes' to define the permissions that the user will have to grant the application. In the ASGI's case, it needs to create, write and read spreadsheets files. After defining the credentials, Google provides an 'API key' to identify the specific application and a 'client ID' that is used by Google API to define the needed permissions.

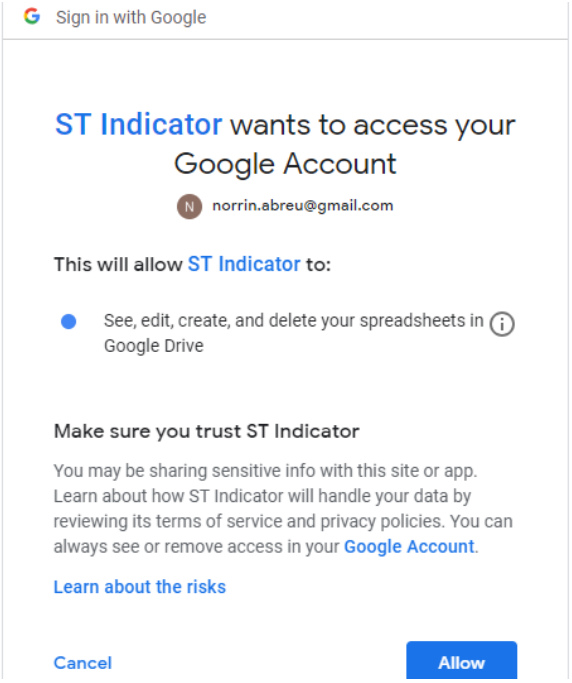

Figure 6. OAuth Consent Screen

4.6 Battery

The battery used in this project is the 7.2V Robot Battery NiMH 3000mAh from VEX EDR. The advantages of using this battery are the fact it is rechargeable, the price in comparison to disposable batteries, its durability, and 8 hr. battery life. The Raspberry Pi needs 5V input, so the battery is connected using a 5V step-down circuit (Fig.7). The ASGI displays the live battery level reading to prompt the user when recharge is needed. The Arduino Uno is used to measure

the battery voltage, the I2C connection then communicates the battery level ex. 75% full to the Raspberry Pi, which displays the value on the screen.

Figure 7. Battery Setup

4.7 Printed Circuit Board (PCB) Design

The 16 pin ADC can be divided into analog and digital portions. The main power inputs are VAA for analog voltage and VDD for digital voltage, while GNDA and GNDD are the analog and digital grounds. For the ADC to work the pins are connected in the following way (Fig.8):

- Pin 1 and 2 set the I2C slave address pin, since both are grounded the address is 0x40.
- Pin 3 is a normally closed reset pin
- Pin 4 and Pin 5 are the digital ground and the analog ground respectively
- Pin 6, 7, 10 and 11 set the analog inputs 3, 2, 1 and 0, they connect to the bridge circuit.
- Pins 8 and 9 are reference inputs they are not being used because the analog input is used as the reference.
- Pins 12 and 13 are the analog voltage and digital voltage, they are connected to capacitor because for the power down requirements as specified in the datasheet [6].
- Pin 14 normally closed, is the data ready port, it is connected using a pull up resistor
- Pin 15 is for I2C data input and output
- Pin 16 is the I2C clock.

The schematic also shows the bridge circuit on the left, and the voltage and ground inputs for the PCB on the bottom right.

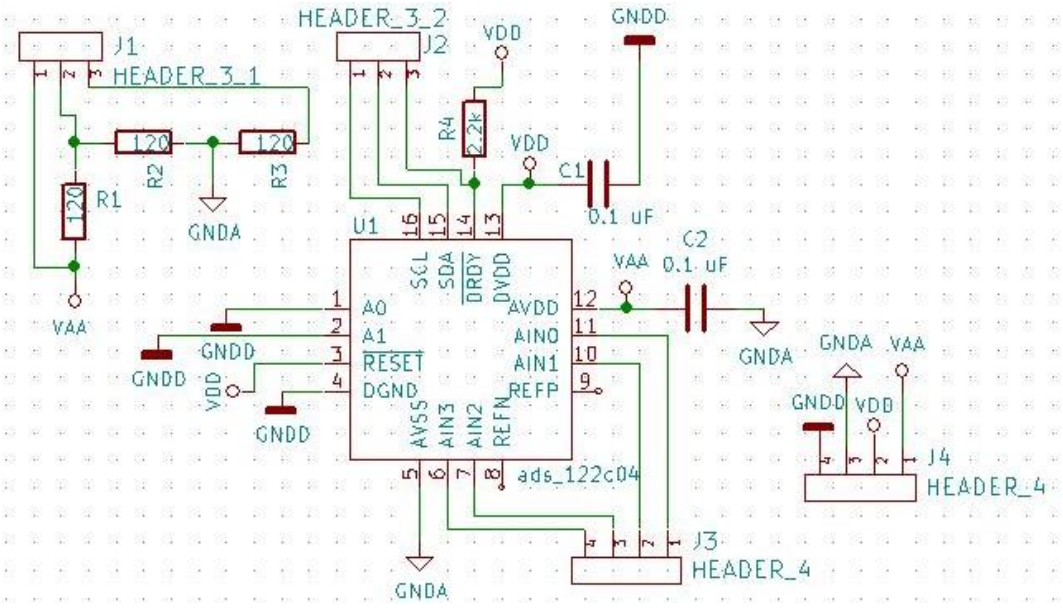

Figure 8. ADC Schematic

The PCB is designed to be as compact and efficient as possible. As seen in Figure 9, the thick cooper lines, 0.762 mm, are used for power connections and the thin copper lines, 0.254 mm, are used for ground and signal connections. The ADC is connected in the center, then the bridge circuit with the three resistors is connected next to it on the bottom left, and (J4) is how power and ground is connected to the PCB. At the top (J3) is how the signal from the strain gauge is connected to the ADC and on the sides are the resistor (R4) and capacitors (C1 and C2) that help with interfacing the ADC. The PCB is a two-layer board and the size is 26.7 mm x 38.1 mm.

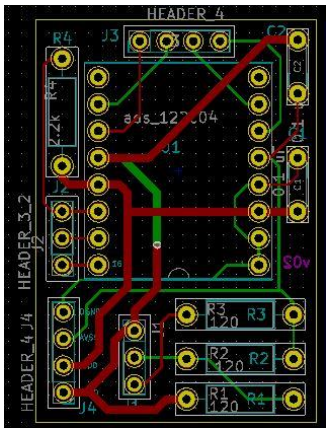

Figure 9. PCB

4.8 Case Design

The case (Fig. 10) was designed to be compact, efficient with space, and sturdy enough to protect the hardware inside. The dimensions are 25.4 cm x 15.2cm x 10.2 cm inch. The case is divided into two halves, the top plate and bottom carrier. The top plate is where the screen, the flash drive input, the Ethernet input and the strain gauge terminals are attached, all of which the user sees. The bottom carrier is where the hardware like battery, multiple chips and charger are contained. Each of the components has a place and the carrier is organized in a way that makes it easy to assemble and to troubleshoot.

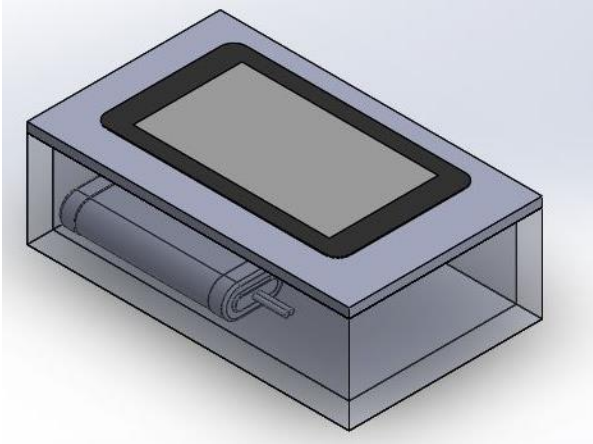

Figure 10. CAD of Case

5. CONCLUSION

Strain measurement is an integral part of manufacturing, since it can provide values for multiple materials. This project set out to make an affordable and modern version equipped with USB flash memory and cloud storage of a strain measuring device, without sacrificing the reliability of the data acquisition. The strain measuring device, P3, with the biggest market share has the retail price of $2000. The ASGI project set out to beat the P3, and with an accuracy of 1 macro strain, at a sampling rate of 20 SP, it is 20 times faster and costs approx. $450 to manufacture, thus rendering this project a success.

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Deadlock Machine

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ABSTRACT

This team is creating a deadlifting mechanism that will be one of the first of its kind in the fitness industry. Deadlift mechanics are used in everyday life and are one of the oldest and simplest basic motions of humankind. The practice of a deadlift is complex, and if executed incorrectly, the deadlift can do more harm than good to the body. This project aims to provide aid to physical therapy and introduce the basic motion of lifting deadweight for patients in a safe and proper manner. This mechanism incorporates resistance bands as well as an adjustable platform, giving the therapist and trainer the ability to customize the exercise based on the user's needs. Since the equipment is to be used primarily in a physical therapy setting, all users will be given the opportunity to **Rehabilitate, Learn, Strengthen, and Perform (RLSP)** a deadlift and improve overall mobility and strength.

1. INTRODUCTION

Deadlifting is a popular practice to increase muscle strength and volume in terms of mass. This workout engages multiple muscle groups of the body, in unison, to perform a task, as shown in *Figure 1*. According to the Poliquin Group, a business dedicated to health-related research, education, coaching, and trainer certification, deadlifting can be used to improve a person's health in many ways. One of the most important points the Poliquin Group makes is that the deadlift has been found to improve movement patterns in the lower body; trainees have better coordination in the hip and knee joints after a 6-week program that includes deadlift. The risk of

a hip and knee injury such as the ubiquitous ACL tear is greatly reduced after only six weeks of this regimen. The group goes on to state that this exercise improves bone strength and reduces the chance of fracture because it loads the hips, knees, and joints making it a fundamental movement that can teach people to perform everyday activities without risking injuries.

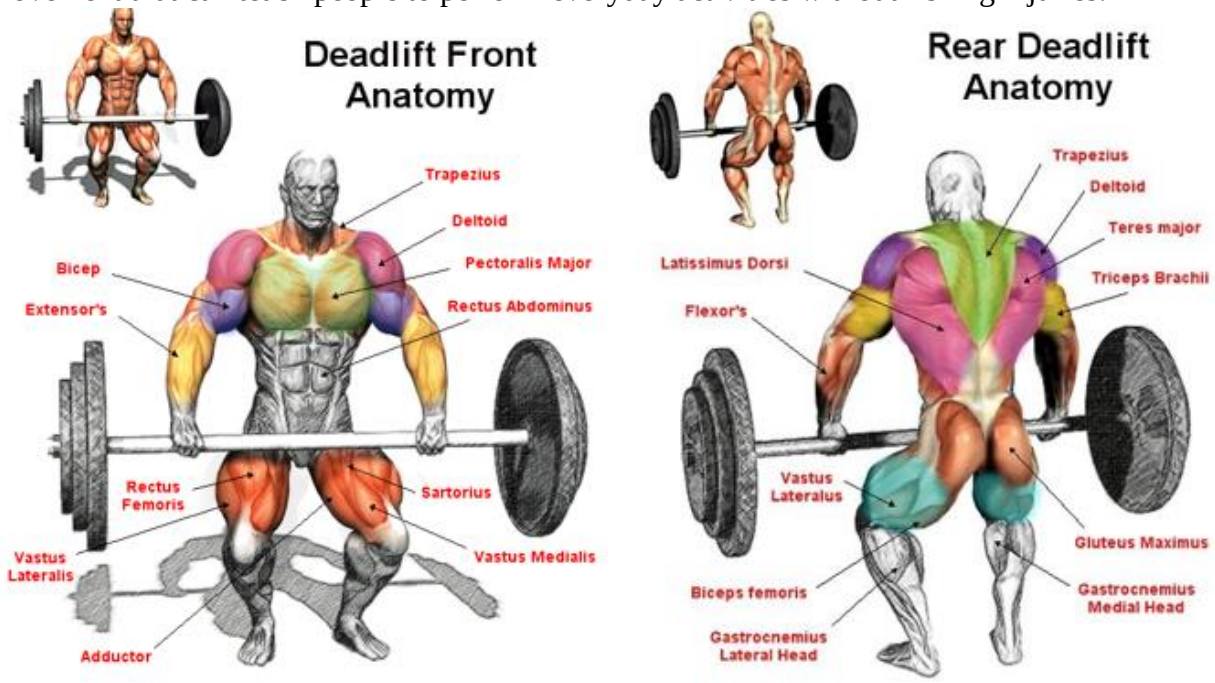

Figure 1: Front (left) and rear (right) deadlift anatomy

This project aims to build an apparatus eliminating the high risk of injury while improperly performing the deadlift movement, thus making it safe for physical therapists to use to improve their patients' well-being. The only machine currently in the market being used for deadlifts is a shrug machine, seen in Figure 2. The Smith machine is also used as an option for simulating the deadlift motion. Both machines are alternatives and great ways to perform this exercise, but they lack the functionality and range of motion of an actual deadlift. The shrug machine is hinge dependent, which limits the full range of motion as the bar comes up; while the Smith machine utilizes railings which also limit the range of motion. Our design will feature a moving platform that displaces the patient to various heights with relation to the barbell, which will be loaded with resistance bands to simulate the loads through tension. Every person's physical body composition and strength level differs. A mechanism that caters to everyone's needs in learning and perfecting the deadlift would benefit the fitness industry and health world.

2. PROJECT OBJECTIVE

[i.] Height Adjustable Platform

- Uses an electrical Jack to lift the floor platform to different height settings.

[ii.] Adjustable Tension

- Uses pegs on both sides of the mechanism to adjust different tension settings on the bands.

[iii.] Portable

- Features a retractable wheeling system to facilitate the mobility of the device.

3. ENGINEERING REQUIREMENT

- **Specifications for the mechanism:**
  - Size: 60x36x36 in
- **Specification for the platform:**
  - Size: 36x32x6 in
  - Weight: 80 lbs.
  - Steel beam size: 2x2x.25 in
  - Wooden post size: 4x4x36 in (2 pieces) & 4x4x24 in (2 pieces)
  - Connecting bolt size: ¼ - 7" Hex Bolt
  - Maximum Load: 500 lbs.(user)+135 lbs. (Barbell w/ tension from bands)
  - Max Displacement: 18 in (From low position)
- **Specifications for the electrical jack:**
  - Size: 15x6x4 in
  - Max Load: 4,000 lbs
  - Max Displacement: 18 in
  - Motor voltage capacity: 12V
  - Motor Current Capacity: 15 A
- **Specifications for resistance bands:**
  - Size: 41x1.13x.18 in
  - Resistance Capacity: 65 lbs. per band
  - Stretch capacity: 100 in

- **Mobility requirements:** The entire mechanism will be placed on top of a set of wheels that will have capacity well beyond the overall weight of the mechanism. This will allow for the mechanism to be moved around a facility with ease.
- **Safety requirements:** When the mechanism is in use, it will be placed on steel footings that will protrude about 2-3 inches from the bottom surface of the device, creating a separate mechanical system that will engage and disengage for mobility, instead of just the wheels. When the wheels are engaged, it will be possible to move the mechanism around. When the wheels are disengaged, the mechanism can then be utilized for deadlifting. The platform will be seated on 4 safety pins placed through slotted holes in the C-Brackets, instead of sitting on top of the electrical jack.

4. DESIGN CONCEPTS

Generating Design Concepts:

These concept designs derived from the observation of various modifications and techniques that improve a user's form while performing this exercise. The prototypes were designed to combine different techniques to reduce the risk of injury while deadlifting.

- **First Concept Design:** Concept Design 1 features one rigid frame composed of a deadlift platform with four metal posts attached to the four corners of the platform. The barbell is placed on top of two steel bars with adjustable heights. The resistance bands are wrapped around the pegs attached on the outer facing side of the metal post, perpendicular to the two steel bars holding the barbell. An issue with this design is that it does not address the mobility requirement established for this project.

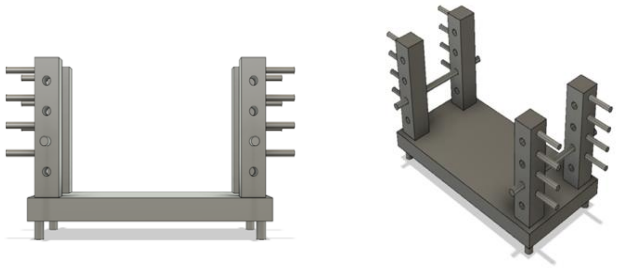

Figure 2: Front (left) & Isometric (right) views of the first concept design

- **Second Concept Design:** Concept design two features a more portable machine. This design makes the platform more practical, as users can disassemble the device and save space through storage. The device features two pyramid-style boxes housing the pegs where the resistance bands would have been anchored. An issue with this concept is that the only way to ensure the safety of the user is to bolt the base of the lifting platform to the ground to make it sturdy, thus rendering the mechanism immobile.

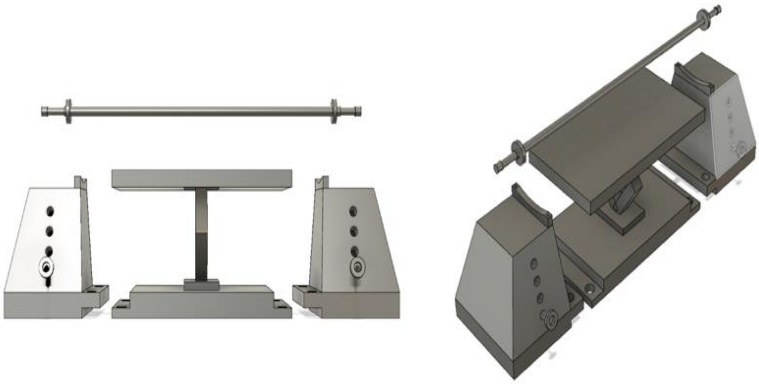

Figure 3: Front (left) & Isometric (right) views of the second concept design

- **Concept Design Three:** Concept design three features a design with a more stable platform. This design is more focused on the stability of the device to ensure maximum performance. Also, this design can easily accommodate a system that will ensure mobility without sacrificing safety standards.

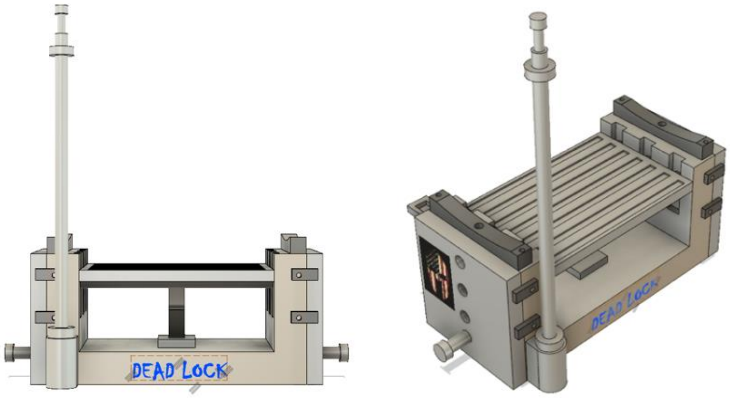

Figure 4: Front (left) & Isometric (right) views of the third concept design

Selecting a concept design:

After evaluating the different concepts, the design with the least number of complications was selected. There are many ways to solve a problem, but the simplest design will make this device simple and safe for exercise use. Concept Design Three was selected for this project due to the stability it offers to the user. This design can incorporate the best of previous design ideas and combine them into one compact design.

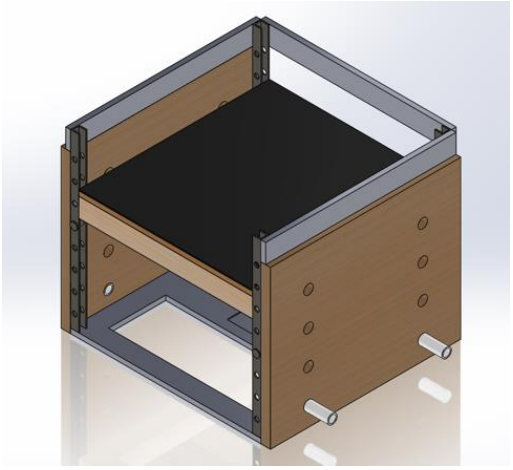

Figure 5: Anticipated finished box product (without jack)

5. ANALYSIS (in progress)

When in operation, the mechanism will be rated to handle up to a 500 lb. person. This weight along with the weight of the barbell with maximum tension from the resistance bands will be the maximum operating load for the mechanism *(Eq. 1).*

Maximum operating force:

$$F_{MOL} = F_{user} + F_{barbell\ w/tension} \qquad Eq.\ 1$$

Where:

F_{MOL}= Maximum operating load

F_{user}= 500 lbs.

$F_{barbell\ w/tension}$ = 145 lbs.

F_{MOL} = 500lbs. + 145 lbs. = 645 lbs.

Knowing the maximum amount of force the platform must withstand, stress analysis for the platform must be conducted to determine which materials will be needed. Since the entire platform will be placed on top of four safety pins slotted through C-brackets, a material with a higher shearing strength must be selected. The reason the shearing strength is the mechanical property of interest is because these pins will only experience a shear force (*Fig. 6)* when the

mechanism is in use. For that reason, the safety pins and guiding pins will be made with mild steel with a tensile strength of 51,000 psi [7]. Shearing strength can be found using a conversion factor from a range of 0.58-0.62 for mild steel *(Eq.2).* For a safe design, we are going to be using a safety factor of 2.

Shearing stress of mild steel:

$$\tau_{yp} = 0.6 * \sigma_{yp} \qquad \textit{Eq. 2}$$

Where:

σ_{yp} = 51,000 psi

τ_{yp} = 0.6* 51,000 psi = 30,600 psi

Allowable shearing stress:

$$\frac{\tau_{yp}}{N_{fs}} = \frac{30{,}600\ psi}{2} \leq 15{,}300\ psi \qquad \textit{Eq. 3}$$

Knowing how much allowable shearing stress these components must be able to withstand plus the maximum force that will be applied on the platform, allows for the calculation of the critical diameter of the pins *(Eq. 4).*

Finding critical diameter for pins:

$$D_c = \sqrt{\frac{4F}{\tau_{All} * \pi}} \qquad \textit{Eq. 4}$$

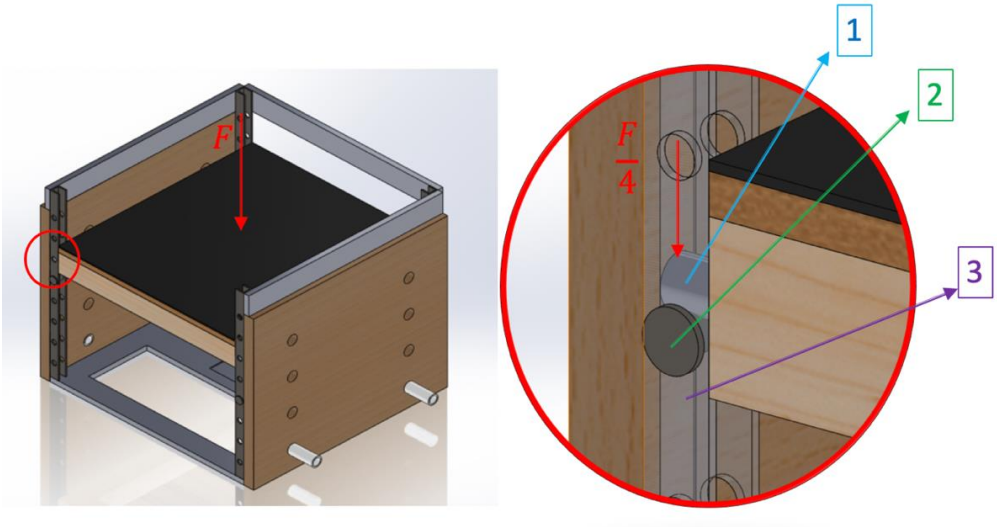

Figure 6: Expected final product (left) with applied force acting the platform. On the right, we have a close up of one of the contact points with the distributed force. Reference point 1: points out the guiding pin, 2: points out the safety pin, 3: C-bracket

6. MANUFACTURING (In progress)

To begin the manufacturing process, the dimensions of the mechanism were selected as 5x3x3 feet. The platform frame has an outer dimension of approximately 36x32 in. We selected a wooden box frame consisting of a 4x4x96 in. post cut into four pieces, two of which measure 36 in. in length and the other two being 24 in. We used eight 16-gauge galvanized heavy tie plates

(2 on each corner, top, and bottom) to fasten the four pieces of wood together. Each plate was screwed onto the wood with 12 #9 x 1 ½ in screws (6 per each side).

Figure 7: 16-gage galvanized steel tie-plates

Figure *8*: Assembled wooden platform frame

7. FUTURE WORK

The team is currently working on finishing the assembly of the platform. As seen in the previous section, we have manufactured and assembled the wooden frame of the platform. We have set up a meeting with Alin Gifardo, an Ironworker, to discuss different concepts and ideas for the welded assemblies of our device; the CAD models will be modified to the specific values to begin production of these parts upon the suggestion of the Ironworker. The future works to be accomplished include:

- The detailed design and assembly of the top plate along with the inserts that complete the platform frame. This is an important design for the project as it will provide a level "floor" for the users to step onto the platform.
- Once the platform is designed and assembled, we can begin simulating the analysis on CATIA V5/SolidWorks. This design is critical as it will determine the detailed dimensions of the interacting assemblies that are experiencing any stress.
- Once the analysis results are obtained, we can apply our knowledge of machine and structure design to determine the critical dimensions necessary for a safe design.
- Detailed design completion of the side plates that will house the pegs on which the bands will be hooked. Once this design has been revised and released, we can begin manufacturing the plates to the desired dimensions, as well as the desired features to house the pegs.
- The X-Frame *(Fig. 9)* detailed design that will be mounted on the bottom of the platform frame *(Fig. 9)* must be revised and finalized to submit to the Ironworker for welding. This design is critical to the project as it will be carrying/transferring most of the loads from the platform onto the jack, while the jack is in use.
- Finish building the platform and get the design of the U-Frame *(Fig. 10).* Once the U-Frame detailed design has been finalized, we can submit this to the Ironworker to begin welding the frame together.

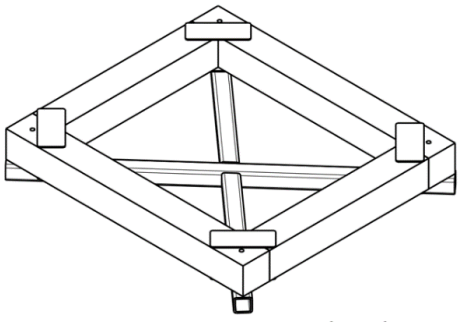

Figure 9: Platform frame (rectangular boxed frame) assembled with X-frame (bottom X-shape frame)

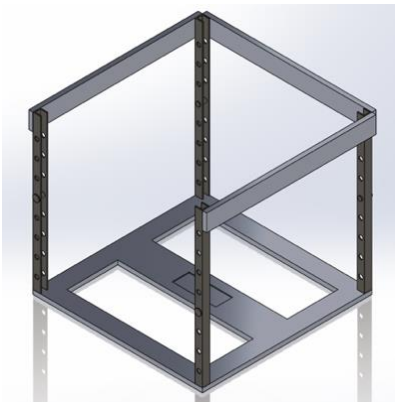

Figure 10: Illustration of the U-frame without wooden walls

8. CONCLUSION

From the moment we are born we are in constant motion and only cease to move in death; this means that for however long a person may live, he or she is constantly exercising in one form or another. Some individuals may not recognize that the exercises performed in a gym can translate to everyday life. One such exercise is the deadlift; the proposed design will allow patients undergoing physical therapy to benefit from this movement. By reducing the distance that a person displaces the bar and utilizing resistance bands in place of weights, the patient will be able to focus on executing proper form. The proposed design includes ease of transport via wheels placed on the bottom of the structure which will sit on stands when in use. Using a combination of wood and steel will allow for a more economic design when compared to similar equipment already on the market, none of which has been chosen for patient rehabilitation. This new design will allow physical therapists to work on a strengthening program with their patients, a development allowing them to track patient progress in a more realistic manner. A common rehabilitation exercise taught to patients with back injuries is one where the patient picks up articles from the ground. After learning the exercise, the patient will be told to practice this movement at home to strengthen the muscles. With equipment such as this invention, the therapist will be able to supervise and gauge the progress made by the patient, therefore, reducing the risk of injury due to improper form.

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The Seeker: Development of Underwater Inspection Vehicle

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ABSTRACT

This paper presents the development of an underwater inspection vehicle. This design consists of a submarine that attaches to a drone through a tether. The submarine is used to inspect large structures grounded in the water, such as an oil rig or the supports of a bridge. The vehicle can be launched by a carrier to an inspection site potentially inaccessible to humans. However, the camera on the submarine allows an operator to remotely observe the aquatic equipment under examination. Once the submarine completes its checking routine, the drone will extract the vehicle back to its home position. This system can be used in both commercial and personal endeavors.

Keywords: Inspection, Submersible, Portable

1. INTRODUCTION

A critical factor in maintaining structural integrity is routine inspections. These inspections can be inconvenient and expensive, since outside contractors, such as divers, have to be invited to safely examine the facilities. The more recent introduction of drones greatly improves the aerial inspections of large structures. However, underwater devices for similar purposes are still not fully explored. The goal of this project is to design a small submersible vehicle which can efficiently conduct the inspection of underwater structures.

The developed submarine contains three DC motors and a camera. The motors are used to turn the vehicle down, left and right, in water and they are remotely controlled by an operator. The camera takes the video underwater for the operator to check the structure requiring inspection. The submarine is launched and extracted by a drone, a carrier to take it to the designated zone. The image data recorded by the on-board camera is sent through the tether to the drone and then through the wireless transmitter and receiver to the remote operator. Since the examiner can directly observe the environment to be inspected through the on-board camera, he/she can make decisions by using the gathered data more effectively.

2. BACKGROUND RESEARCH

Currently, for large water structure inspections, there are large submarines capable of doing a very detailed inspection. These submarines come equipped with multiple sensors to give the operator large amounts of data. These submarines are taken to inspection sites via a small boat and are launched using a crane. An example is the 10-feet unmanned inspection submarine, created by Lockheed Martin that can map 135-feet within 27 minutes [1].

Multi-terrain drones are currently being studied in a number of universities and institutes across the country. Since this is a very new concept, most researchers are limited to building a vehicle that can both fly in the air and dive into the water. For example, a flying and diving robot, created by Rutgers University, is shown in Figure 1 [2]. This vehicle is controlled via a tether that connects to a remote control. The advantage of this approach is that data information can be safely delivered to the drone. The disadvantage, however, is the vehicle can only go as far as the length of the tether.

Figure 1: Rutgers Underwater Drone

Compared to the above techniques, our designed product is smaller in size and more flexible to launch and extract. The submarine is also simpler and cheaper than an underwater drone for inspection.

3. ENGINEERING REQUIREMENTS AND DESIGN CONSTRAINTS

3.1. ENGINEERING REQUIREMENTS

- Submarine
  - Size: 177mm × 93mm × 143mm
  - Weight: 204 g
  - Materials: PLA Filament
  - Continuous Operation: 30 min
  - Battery: 5000mAh LiPo
- Motor
  - Type: DC Brushless Motor
  - Diameter: 30mm
  - Power: 140W
  - Current: 11A

    - Voltage: 7.4~14.4V
- ➢ Battery
    - Minimum Capacity: 5000mAh
    - Configuration: 11.1V = 3S
    - Weight: 360g
    - Size: 143 × 51 × 23 mm
- ➢ Electronic Speed Controller (ESC)
    - Continuous Current: 12A
    - BEC Included
- ➢ Camera
    - LED backlight
    - Ultra-Micro FPV Camera and VTX
        - Band: 0-8MHz
        - Weight: 9.16g (with case)
        - Resolution: 800TVL

3.2. ENGINEERING CONSTRAINTS

- Carrier (Drone)
    - The submarine must be small enough to be carried by an aerial vehicle
    - The drone must be able to hold the pulley system
- Economic
    - The cost of the vehicle with drone must be reasonable for multiple markets that could use this inspection tool
- Environmental
    - The vehicle must not harm the sea life
- Health and Safety
    - The vehicle must not harm humans

4. SUBMARINE DESIGN

The size and shape of the robot are necessary factors to consider in order to optimize the submarine's underwater movement. Criteria include electronic and material selection and shape. Weight should be considered in the vehicle design, since it will be carried and deployed by an aerial vehicle.

4.1. SUBMARINE BODY DESIGN

4.1.1. MATERIAL SELECTIONS

- Maximum Pressure Threshold for Materials

The main material used in this project is poly-lactic acid (PLA). PLA has the maximum yield strength of 2400 psi on standard settings [3]. The amount of pressure experienced underwater is equivalent to:

$$P = \left(\frac{d}{10} + 1\right) \times S \quad (1)$$

where,

P = pressure
d = distance submerged in water
S = 14.5 psi (standard pressure at sea level)

Equation (1) is used to determine the amount of pressure. According to it, the maximum depth, *d*, for the submarine in the water is calculated as follows.

$$13600\ psi = \left(\frac{d}{10} + 1\right) \times S => d = 9369.31\ meters \quad (2)$$

Using this data, it was found that the deepest part of water that the material can go without crushing is 9369.31 meters, which means that PLA will work for inspection purposes for the most general cases [4].

4.1.2. MOTOR SELECTIONS

- Power and Drag Equations

The drag is necessary to determine how many resources the submarine needs to reserve for the motors. Using the drag equation (3), we can compute the power necessary to drive the submarine.

$$Drag\ = \frac{\rho \times A \times V^2 \times C_d}{2} \quad (3)$$

where,

ρ = density of the seawater / gravitational acceleration (~1029 kg/m3)
A = active area affected by the drag
V = velocity
C_d = drag coefficient

However, Equation (3) needs to be modified since there is a tether attached to the submarine. When the tether is considered, the new drag formula is as follows,

$$Drag\ = \sum_{i=1}^{n} \frac{\rho \times A_i \times V^2 \times C_{d_i}}{2} \quad (4)$$

The following equations are used to calculate the different areas in the submarine,

$$A_{submarine} = l \times w = (3 + 2 \times 2.5) \times 2.5\ \times 0.0254^2 = 0.00642\ (m^2) \quad (5)$$

$$A_{tether} = 8 \times 0.33 \times 0.0254 = 0.2032(m^2) \quad (6)$$

For the submarine designed in the project, the velocity is selected as around 3 mph = 1.34 m/s, C_d for a rectangular cross-section is around 2.0 and for a circular cross-section is around 1.17, respectively [5]. Therefore, we have the following calculation results.

$$Drag_{submarine}\ = \frac{\rho \times A \times V^2 \times Cd}{2} = \frac{1029 \times 0.00642 \times 1.34^2 \times 2.0}{2} = 8.865\ N \quad (7)$$

$$Drag_{tether}\ = \frac{\rho \times A \times V^2 \times Cd}{2} = \frac{1029 \times 0.2032 \times 1.34^2 \times 1.17}{2} = 164.152\ N \quad (8)$$

By adding Equation (7) and Equation (8), the total drag is 173.017 N. For the drag that the submarine consumed, the amount of power is as follows:

$$\text{Power} = (\text{drag} \times V) / 550 = (173.017 \times 1.34) / 550 = 0.422 \text{ W} \quad (9)$$

It takes the power of more than 0.422W for the submarine to move 8 feet under the water surface [6].

The motor chosen to run the submarine is the Turnigy Aero drive DST-700 brushless out runner motor 700kV, as shown in Figure 2. The maximum voltage and current of the motor are 14.4V and 11A, respectively. It provides an output power up to 140W [7].

Figure 2: Turnigy Aero Drive DST-700 Brushless Out Runner Motor 700kV

The motor is attached to an Electronic Speed Controller (ESC) that has a maximum current rating of 12A, as shown in Figure 3. The ESCs purpose is to control the motors speed and direction (clockwise or counter-clockwise).

Figure 3: Electronic Speed Controller (ESC)

A Lithium Polymer (LiPo) battery is required for the submarine to work. A three-cell (3S) battery containing a voltage of 11.1V is chosen. The duration of the submarine can be calculated below:

$$operation\ time\ =\ battery\ capacity\ /\ current\ draw \quad (10)$$

$$operation\ time\ =\ battery\ capacity\ /\ (battery\ capacity\ \times discharge\ rate) \quad (11)$$

The 3S battery in use has a capacity of 5000mAh with a discharge range of 20-30C, see Figure 4 for details. The motors have a current draw of 11A. By combining all three motors, the total current draw is 33A. Using Equation (11), the operation time under the maximum setting is around 9 minutes. When the motors are idle, the operation time is around 30 minutes.

Figure 4: 3S Battery

Figure 5: Propellers

Attached to each motor is a differently angled propeller depending on the direction of motor spinning, as seen in Figure 5. Propellers are essential to make the submarine move as it converts rotational motion into thrust.

4.1.4. CAMERA SELECTION

The camera is a main part of the submarine, as this device gives a user the first-person point of view. Throughout the project, we have tested two different cameras, both can be seen in Figure 6. The first camera tested is the one shown on the right. This camera had a low video quality. We tested it by extending the coaxial and the quality drastically decreased. A second camera was then purchased with a higher price; this camera can be seen on the left of Figure 6, and it allowed us to extend the coaxial with ease.

Figure 6: Camera with FPV Transmitter

4.2. DESIGN CONCEPTS

In order to create the best design for the submarine, the required components were reviewed, and their dimensions were computed. Once all the requirements were recorded, the parts for the submarine were designed and created using Solidworks, a CAD software environment. The first parts designed were the side motor mounts. These mounts need to house the motors and have a shield for each corresponding propeller. The connection between the motor holder and the propeller shield is the critical point of the motor mount that needs to be designed to withstand the required force generated by the water movement, i.e. the water will constantly move in and out of this section. The motor mounts also need to connect to the main structure of the submarine. In order to do this, flanges were added to the bottom of the mount, which allow for a strong connection point between the two parts.

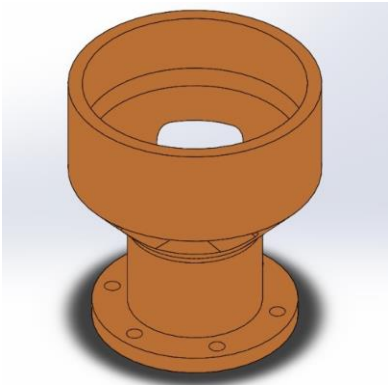

Figure 7: Side Motor Mount

The second part of the submarine is the main housing, as displayed in Figure 8. Inside of the main housing is where the central motor, the camera, and all of the ESCs are located. This part is essential to combine all of the pieces together. The two motor mounts connect to the flanges on the left and right of the main housing. The remaining wires from the ESCs go out from the tether hole on the top. The camera is placed in the top fitting and wired to the tether hole as well. Finally, the center motor is placed into its housing and tightened, followed by the connection of an ESC. Once all the electronic components and 3D printed parts are put into place, the gaps on the main housing are covered in Lexan, marine weld, and silicone to waterproof the submarine.

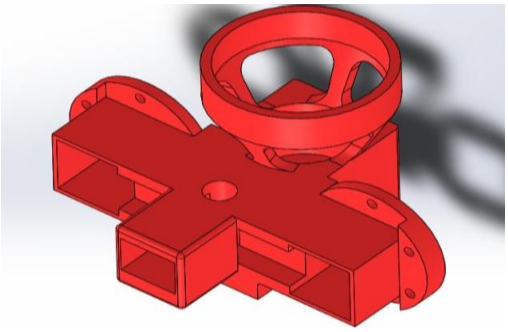

Figure 8: Center Motor Mount and Main Housing

The first type of sealant used was marine weld to hold down the Lexan. Then silicone was placed over the edges of the Lexan and on the edges of the flanges. Once everything settled, the wires were all extended to 8 feet for testing. The wires were then placed into a tether tubing and were connected to their respective endpoints. The power and ground for the motor are connected to the battery, the signal wires for the motors are connected to the transmitter for the remote control, and the camera signal wires are connected to the transmitter for the camera.

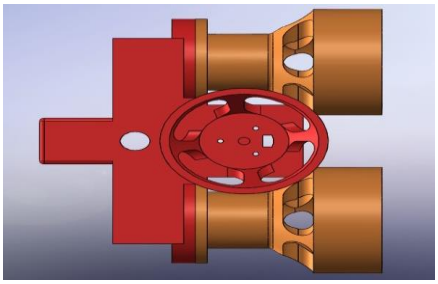

Figure 9: Full Submarine Assembly

5. CONCLUSION

The development of unmanned inspection vehicles is a rapidly growing field, extremely important to industries. Currently existing vehicles are normally used for aerial or ground inspections. Few vehicles for underwater examination that are portable and intuitive. The vehicle created in this project can not only provide underwater inspections but also can be picked up by a drone to continue aerial evaluation. The designed submarine can be sent to hard–to-reach areas and transmit visual information back to the remote operator. This vehicle can be further improved by making the submarine even more compact, thus allowing any drone to pick up this submarine for inspections.

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Object Detecting Competition Robot

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ABSTRACT

The goal of this project is to develop an Object Detecting Competition Robot for the Vex Robotics Competition, Turning Point in the VexU division. VexU is an international collegiate robotics competition consisting of a tournament and a skills challenge, and this robot will compete in the tournament. The tournament consists of two robots per team competing head to head in a 2 minute and 15 second match consisting of autonomous and driver control periods, where the team that scores the highest at the end of the match wins. Each team consists of two robots, one robot must start inside a 15" cube and one inside a 24" cube; this project will focus on the latter. The project team will attempt various programming techniques for the autonomous period such as Object Detection with a camera. This robot will be designed and built utilizing the VexEDR and VexPro product lines in conjunction custom 3D Printed and CNC Milled designs using SolidWorks parts made on campus.

1. INTRODUCTION

Since 2008, VCAT Robotics has competed in VexU, an international robotics competition created by Vex Robotics. Every year the game changes and students are tasked with designing a robot to compete in the game that is in accordance with the rules and regulations. This season for the competition runs from April to April of the following year ending with the World Championship. This season's game is called Turning Point which is played on a 12'x12' field of foam tiles and is surrounded by a steel and polycarbonate perimeter. There are five ways to score in Turning Point; winning the autonomous period, turning flags for your team color, flipping "caps" on the ground, placing caps on poles, and parking robots on raised platforms on the center of the field at the end of the match. The robot must score in every aspect of the game in order to stay competitive. The robot goes through several iterations throughout the season in order to stay competitive.

Figure 1. Turning Point Field Set Up

2. ENGINEERING REQUIRMENTS

[i] The turning point game manual outlines the rules for the competition and the robot. The first section of the manual outlines how the game will be played, there is a 45 second autonomous period followed by a 1 minute and 15 second driver control period. After the match has ended the field is scored as it is. Teams score as follows.

- **Autonomous Bonus**: is awarded to the team that has the highest score at the end of the autonomous.
- **Flags**: There are 3 flag posts on the field. Flags are scored for the team whose color is showing, the 3 states of a flag are shown in Figure 2, red scored, neutral and blue scored from top to bottom.
  - High Flags are the top two flags, they are 2 points each and can only be toggled using the balls shown in Figure 3.
  - Low Flags are the bottom flags, they are 1 point each and can be turned by a robot.
- **Caps**: Caps are the octagonal elements on the field. They are scored for the team whose color is facing up at the end of the match, worth one point on the ground and 2 on any of the 6 pipes as shown in Figure #4.
- **Platforms**: There are 3 platforms made of 2" PVC pipes with a sheet of Lexan over the top and are about 2' x 2', Fig. 5. Teams are awarded 3 points per robot if they are parked on their corresponding red or blue platform or 6 points per robot on the yellow platform.

Figure 2. Flag Post

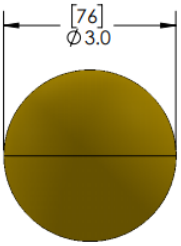

Figure 3. Ball Figure

4. Cap and Cap on Post

Figure 5. Platforms

[ii] There are white tape lines on the field that define zones that effect robot movement throughout the match. The robots cannot cross the double line down the center of the field in autonomous, and robots are not allowed to be taller than the starting 24" height outside of the expansion zone. The expansion zone and autonomous line are marked on the field by white tape.

[iii] Robots are only allowed to possess two balls and one cap at any given time.

[iv] In order to be allowed to compete the robot must pass an inspection to ensure it has met all the regulations in the Turning Point Game Manual and the exceptions in the Appendix E section where the changes for the VexU division are noted. The inspection checks for size, material, electronics, and safety. The rules clearly state that teams must use the Vex V5 architecture to power their robot; this includes the battery, microcontroller, and motors. Any physical modifications of these parts or 3rd party components are illegal and the robot will not pass inspection. However teams are allowed 3rd party sensors and pneumatic components as long as they are rated for at least 100psi.

[v] When it comes to structure robots can be made of any hardware sold by Vex Robotics as part of their VexEDR or VexPro product lines. Teams are allowed to use an unlimited number of machined and 3D printed parts. There is a list of materials as part of <VUR3> in Appendix E of the Turning Point Game Manual that can be used to machine custom components.

[vi] To be competitive the robot must score in every aspect of the game in order to not be limited to one strategy during the competition. The robot must be able to manipulate caps, score flags, and easily climb the platforms.

3. MECHANICAL DESGIN

3.1. Drivetrain

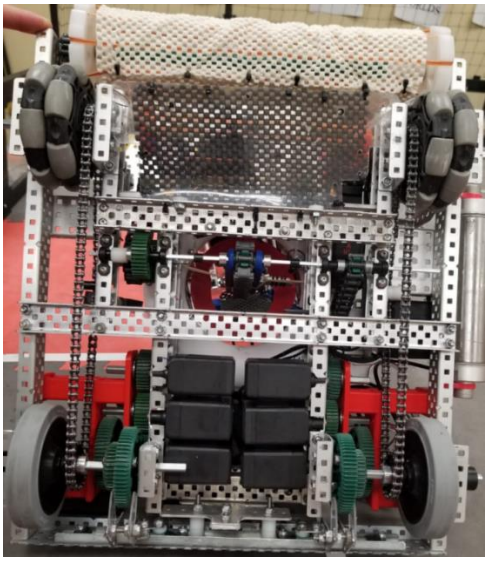

Figure 6. Under Side of Drivetrain

3.2. Frame

On the current iteration of the robot, the frame of the drivetrain was designed to increase mobility on the field. One of the biggest drawbacks to the previous drivetrain was that it was very wide making it hard to climb the platforms. The drive train is stable now at 15" wide and 17" long which is 2" smaller in both directions compared to the previous design.

3.3. Transmission

The drivetrain features a 2-stage transmission for a competitive edge during the driver control period. The transmission allows the robot to get from one side of the field to the other very quickly, and then to switch stages for enough power to push the opponent's robots around. The gear ratio changes from 3:5 in the torque stage outputting 15.49 ft lbf and 5:3 in high-speed stage outputting 5.58 ft lbf using a pneumatic piston to push and pull the gears into place.

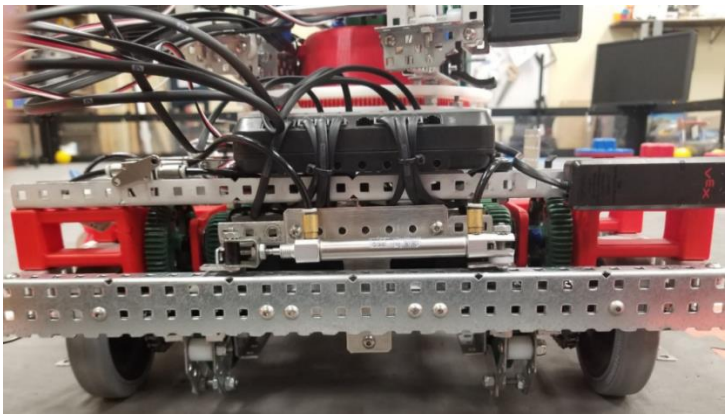

Figure 7. Transmission

3.4. Cap Manipulator

Lift

The lift was designed to be as simple as possible to avoid complications and keep it structurally sound. By measuring the triangle the robot made with the low post, the position and arm length were designed so that the lowest point is the perfect height to grab the cap from the ground and the highest point is the height needed to place the cap on the post.

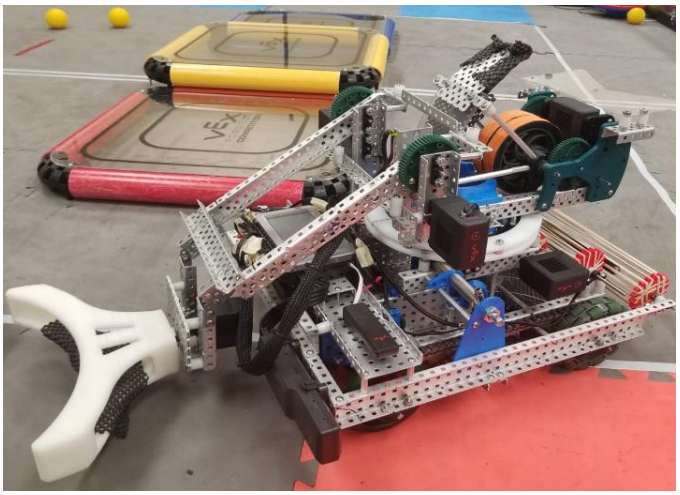

Figure 8. Lift at Bottom Position

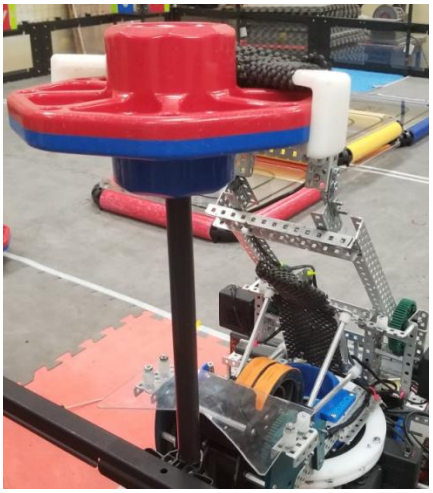

Figure 9. Lift at Top Position

Claw

The claw, Fig. 10, is designed for the cap to slide in and spin in order to change the color of the cap. It has to be mounted to a ¼" shaft because the ⅛" shaft kept bending. To do this, the CNC milled an aluminum shaft collar with flanges to keep the claw on the shaft, Fig. 11. A shaft collar, Fig. 11, was milled and the set screw is used as a mechanical stop to prevent the claw from spinning more than 180°.

Figure 10. The Claw

Figure 11. Shaft Collars

3.5. Ball Launcher

Camera Tracking Turret

The application of a camera tracking turret greatly increases the accuracy of the robot in autonomous and driver by reducing the need for turning which can be very inconsistent. Using a turret to turn to the flags instead of moving the drive train reduces the number of turns needed thus improving autonomous consistency. The turret is constructed using a 3D printed gearbox and funnel. The gear box provides a 25:1 gear ratio giving the flywheel a max velocity of 5,000 RPM. The funnel is designed so that there is a tight clearance for the ball to come out of the top to the flywheel. The turret is turned using a 3D printed gear and HDPE top and bottom plates.

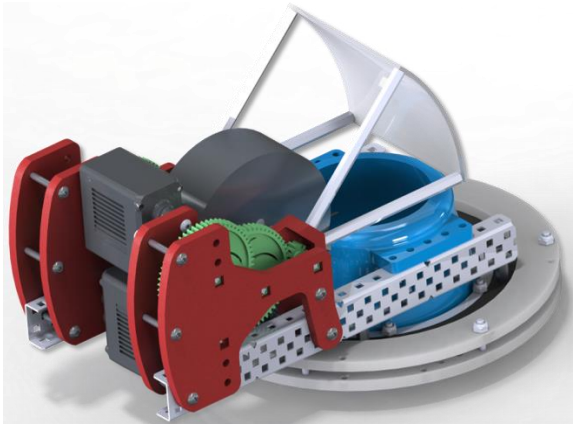

Figure 12. SolidWorks Rendering of the Turret

Flywheel

Our ball launching mechanism is the single flywheel launcher. A flywheel uses the angular velocity of a high speed, weighted wheel to launch a ball. We chose this mechanism after trying other methods to launch the ball; the flywheel proved to be the most consistent and doesn't require much maintenance during competition. Below is a diagram explaining some of the inner workings of the flywheel:

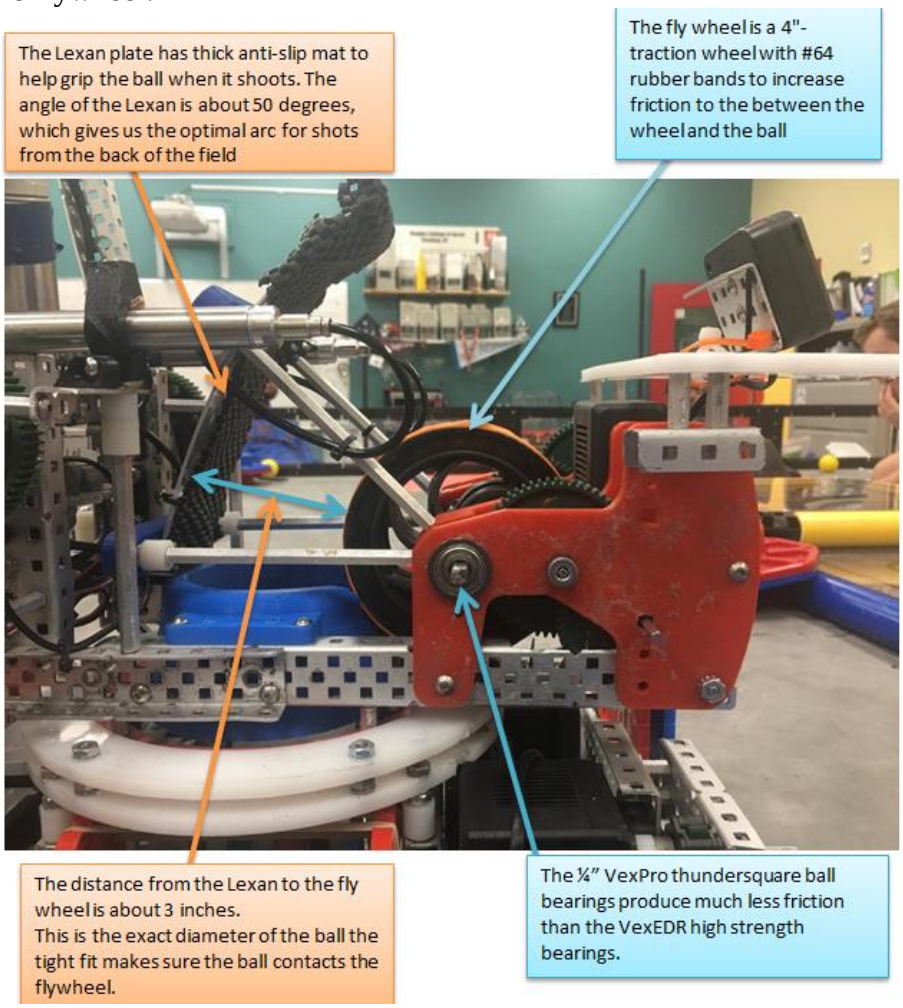

Figure 13. Close Up of Flywheel

3.6. Ball Intake

Rubber Band Rollers

To intake the balls there is a system of 3 rollers made of sprockets with rubber bands connecting them to create a flexible roller. The sprockets spin to roll balls from the field up into the robot. The large front roller, Fig. 14, can also be used to flip caps on the ground by spinning in the opposite direction. The sprockets on the front roller are made of HDPE to be durable enough to use both ends of the robot to push opponents on the field. The intake system utilizes an IR sensor and a limit switch, Fig. 15, to ensure a robot can roll up no more than two balls at once which would be a penalty.

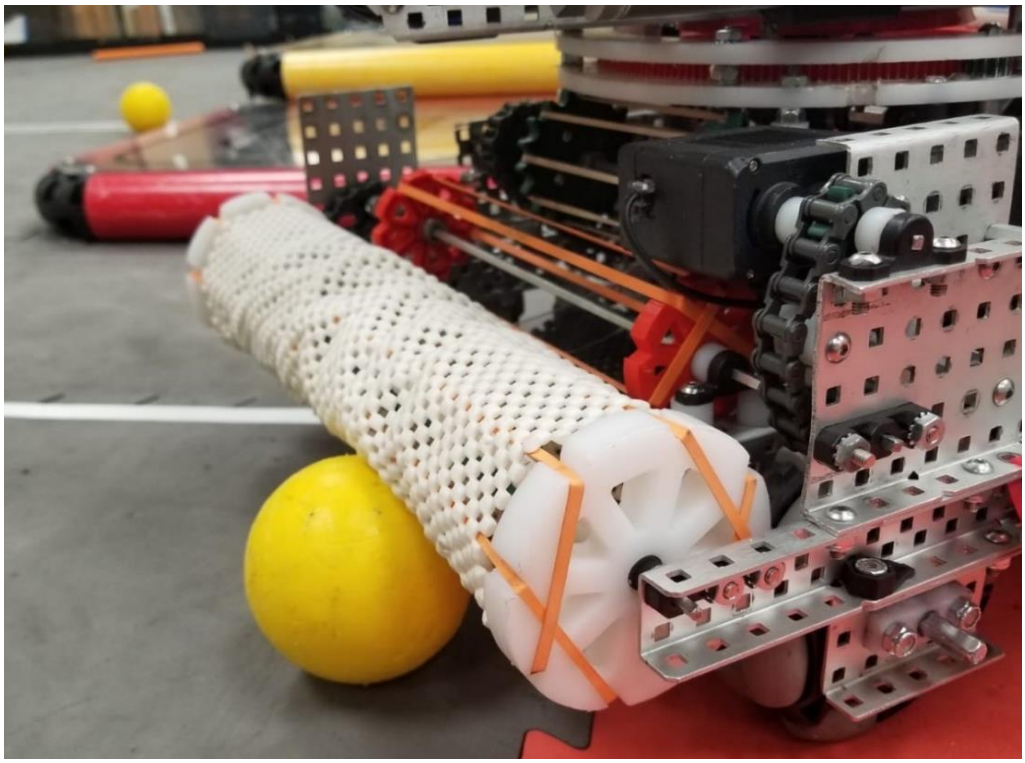

Figure 14. Rubber Band Roller

Figure 15. Limit Switch and IR sensor

Turret Conveyor

In order to get the ball up the funnel a pivoting conveyor belt was designed. The pivot is what allows balls to get up through the funnel one after another, it uses rubber bands hold-up which

lets it spring back to the right place. This allows for a quick double shot to score two flags very quickly.

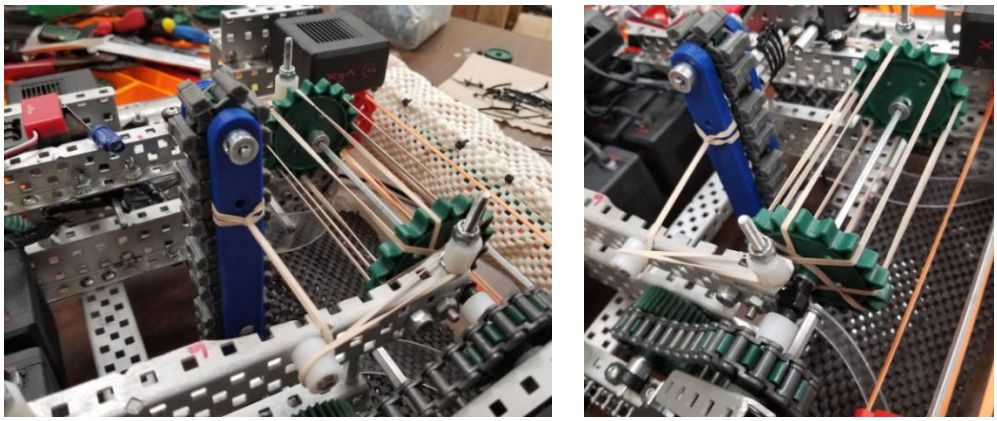

Figure 16. Pivoting Conveyor System

3.7. Pneumatic Lift

Since scoring on the center platform is 6 points per robot, the team wanted to achieve the goal of scoring both robots on the center platform. The platform doesn't have enough space for two robots, so a lift was designed and the 24" robot can tilt the 15" robot onto the platform. Since both robots are contacting the center platform and not the tiles or alliance platform this is a 12 point move. The lift consists of 2 pneumatic pistons with a 6" stroke that can put out 25lbs of force at 100psi. Two pistons were added for structural stability and durability, although one piston has enough force to tilt the smaller robot. Some calculations are made for this mechanism to find the theoretical stress applied on the piston near the fixed end.

Bending Stress Analysis Due to Lift Weight of Robot

Two pistons that are connected to the frame of the first robot are used to lift the second robot from the platform, thus applying bending stress to both ends of the hollow piston and bolt that is connecting the piston to the frame of first robot (Figures 7 and 8).

Piston Safety Analysis: Bending stress due to weight of Robot on fixed end of hollow piston can be expressed as

$$\sigma_{applied} = \frac{M * C}{I} \qquad (1)$$

Moment due to Smaller Robot weight at end of piston is

$$M = F * d \qquad (2)$$

Where, F = 10 lb, d = 5 in. Hence, moment at the fixed end can be expressed as

$$M = 10\ lb * 5\ in = 50\ lb - in$$

The moment of inertia of Hollow piston at fixed end is

$$I = \frac{\pi}{64} \left(d_o^4 - d_i^4 \right) \quad (3)$$

Where, d_o = 0.62 in, d_i = 0.43 in

$$I = \frac{\pi}{64} \left((0.62 \text{ in}^4) - (0.43 \text{ in}^4) \right) = 5.455 * 10^{-3} \text{ in}^4$$

Center of Shape of Piston Cross Section

$$C = \frac{d_o}{2} = \frac{0.62}{2} = 0.31 \text{ in} \quad (4)$$

Hence, bending stress at the end of hollow piston can be calculated as follow

$$(\sigma_{\text{Applied}}) = \frac{(50 \text{ lb} - \text{in}) * (0.31 \text{ in})}{(5.455 * 10^{-3} \text{ in}^4)} = 2.84 \text{ ksi}$$

Factor of Safety of piston under applied stress can be expressed as

$$FS = \frac{\sigma_{\text{ultimate}}}{\sigma_{\text{applied}}} \quad (5)$$

Where, $\sigma_{\text{ultimate}} = 88.5$ ksi and $\sigma_{\text{applied}} = 2.84$ ksi, $FS = \frac{88.5 \text{ ksi}}{2.84 \text{ ksi}} = 31.16$

This indicates that the piston has a high factor of safety relative to ultimate strength and hence it can safely provide support to lift the second robot from platform.

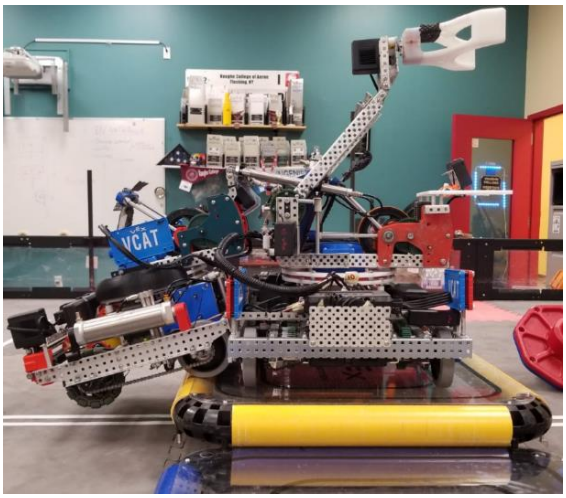

Figure 17. Scored Double Lift

Bolt Safety Analysis: Two bolts connecting each piston to the frame of the first robot are used as support to lift the 2nd robot, thus creating a bending stress expressed by equation 1, $\sigma_{applied} = \frac{M*C}{I}$, the moment of inertia of bolt cross section can be calculated as $I = \frac{\pi}{64} d^4 = \frac{\pi}{64}(0.2^4) = 7.854x10^{-5}$ in, $C = \frac{d}{2} = \frac{0.2}{2} = 0.1\ in$, and each bolt carry 50/4 lb-in moment, hence

bending stress exerted to each bolt can be calculated as follows

$$(\sigma_{\text{Applied}}) = \frac{(50/4\ lb - in) * (0.1in)}{(7.854 * 10^{-5}\ in^4\ )} = 15.9\ ksi$$

The factor of safety of steel bolt under applied stress can be calculated as follows:

$$\text{FS} = \frac{\sigma_{\text{ultimate}}}{\sigma_{\text{applied}}} = \frac{75}{15.9} = 4.72$$

Based on the above calculation, each supporting bolt has a factor of safety of 5 relative to the ultimate strength of the bolt. Even though the factor of safety of the supporting bolt is not as high as the piston, it is safe enough to lift the 2nd robot from the platform.

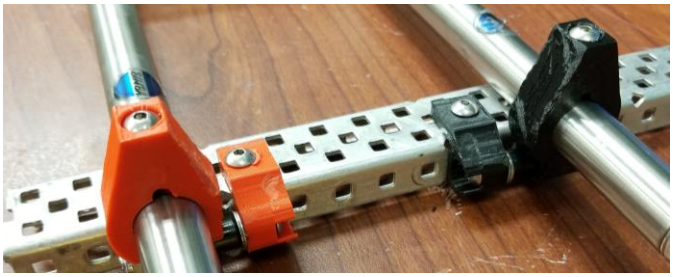

Figure 8: Piston Connection to the Frame of Robot

4. CODING

4.1. Functions

The robot is programmed using the Vex IDE called Vex Coding Studio, which can use C++. Many of the motor's functions are created using the PID control built in to the motors. However, other algorithms are created to control robot functions such as turning and driving in a straight line. Some of the functions used to control the main mechanisms of the robot are shown below.

```
int RPMCalc(){
    while (1){
        int TempRPM = RPMGoal;
        if (fly == 2 || fly == 3){
            TempRPM = RPMGoal;
            FlyR.spin(vex::directionType::fwd, RPMGoal, vex::velocityUnits::rpm);
            FlyL.spin(vex::directionType::fwd, RPMGoal, vex::velocityUnits::rpm);
            while ((fly == 2 || fly == 3) && RPMGoal == TempRPM){
                rpmError = fabs(RPMGoal - fabs(FlyR.velocity(vex::velocityUnits::rpm)));
                wait(5);
            }
        }
        else{
            FlyL.stop(vex::brakeType::coast); FlyR.stop(vex::brakeType::coast);
            while ((fly == 4 || fly == 1) && RPMGoal == TempRPM) { wait(100); }
        }
        wait(100);
    }
    return 0;
```

Figure 18: RPM Calculation

```
int CapFlipFun(){
    int capDir=1;
    while(1){
        if(Flip180==0){
            run(CapFlip, 60);
            wait(400);
            Flip180=2;
            CapFlip.stop(vex::brakeType::hold);
            capDir=1;
        }
        else if (Flip180==1) {
            CapFlip.rotateFor(180,vex::rotationUnits::deg);
            Flip180=2;
            capDir=1;
        }
        else if (Flip180==3){
            CapFlip.setTimeout(1,vex::timeUnits::sec);
            CapFlip.rotateFor(-180,vex::rotationUnits::deg);
            Flip180=4;
            capDir=-1;
        }
        else if(AutoRunning==1){
            run(CapFlip, 1*capDir);
        }
        else{}
        vex::task::sleep(10);
    }
```

Figure 19. Cap Flip

4.2. Vex Vision Sensor

The vision sensor is a 640 x 400 pixel camera that can track up to 7 different colors at the same time. Vex Coding Studio has a built-in user interface that allows the user to easily calibrate the settings. A filter was programmed to ensure that the camera only tracks flags, and a sample of this filter is shown in Figure 21.

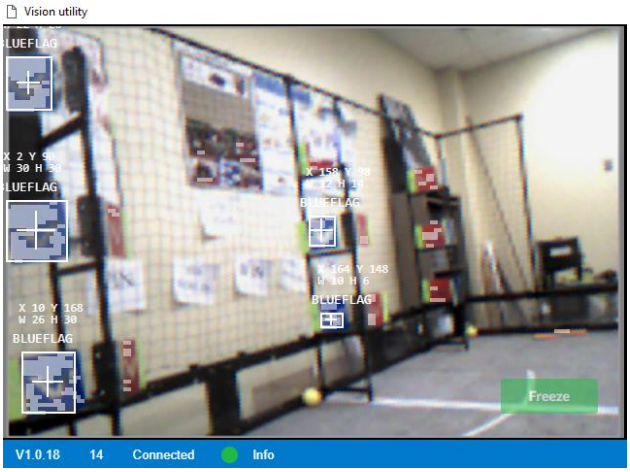

Figure 20: User Interface

```
for (int i = 0; Vision.objects[i].exists == 1; i++){                    //filter objects under the critera:
    if ((Vision.objects[i].width > 8 && Vision.objects[i].height > 8)   //objects under a width and height of 8 pixels
    && (Vision.objects[i].centerX > (GlobalFlagOffset - 10 - TempXDist) //objects with a center x offset of +10 pixels
    && Vision.objects[i].centerX < (GlobalFlagOffset + 10 - TempXDist)) //objects with a center x offset of -10 pixels
    && Vision.objects[i].centerY < TempHeight) {                        //objects aligned to center y of camera
            TempHeight = Vision.objects[i].centerY;                    //resize ideal pixel height
            TempWidth = GlobalFlagOffset - Vision.objects[i].centerX; //resize ideal pixel width
            FlagYDim=Vision.objects[i].height; TempObject=i;          //set pixel height
    }
    else {}
}
```

Figure 21: For Loop Used to Filter and Align Turret

5. CONCLUSION

Throughout this season VCAT Robotics has competed in 3 tournaments and hosted a scrimmage. This season the team has won the Design award, the Excellence award, which qualifies the team to compete in the world championship in April, the Skills Challenge award four times, and has twice been a tournament Finalist. The robot will continue to improve leading up to the championship, including improvements to the angle of the shot.

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Position Control of an Autonomous Unmanned Aerial Vehicle (UAV) Based on Accelerometer Response for Indoor Navigation

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ABSTRACT

Autonomous indoor drone navigation has been posed with various challenges, including the inability to use a Global Position System (GPS). As of now, Unmanned Aerial Vehicles (UAVs) rely either on 3D mapping systems or external camera arrays to track the UAV in an enclosed environment. The objective of this paper is to develop an algorithm so that the UAV can 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.

Keywords: Accelerometer, Position-Control, UAV, Indoor Navigation

1. INTRODUCTION

Unmanned Aerial Vehicles (UAV) have become an essential technology as they move into broad industries such as Search and Rescue, Building Inspections, Agriculture, and Emergency Aid. Different aspects of UAVs are continually researched to develop more advanced and smarter drones. This research focuses on developing an algorithm to achieve indoor autonomous position-control with the aid of an onboard accelerometer only. Developing such an algorithm will eliminate the need to implement advanced sensors or external cameras.

2. OBJECTIVE

The goal of this research is to develop an algorithm that efficiently allows the UAV to perform position-control in an enclosed environment autonomously. The robot simulation environment will be used to test and develop the algorithm. The algorithm will consist of measuring accelerations from the accelerometer, rotating the body frame into the inertial frame, and double integrating accelerations to yield position estimates.

The algorithm will also incorporate multi-threading to correct the UAV drift in real time by controlling the roll and pitch values of the UAV for stable positioning. To account for the errors introduced during double integration, the researchers will use an error factor, which will be obtained through experimentation to yield adequate results. After obtaining stable results in the simulation, the algorithm will be tested on a real-world drone.

3. BACKGROUND RESEARCH

Through our research, a journal article [1] that proposes a method to estimate the displacement of a UAV in an enclosed environment was found. This method describes an algorithm with the capability of navigating the UAV through a certain distance by mainly utilizing the onboard Inertial Measurement Unit (IMU). Additionally, the algorithm is also capable of minimizing the error between the desired displacement and the actual displacement travelled by the UAV. The idea described in the article is similar to the proposed methodology, however our approach varies. In the article, a flight controller with an ATMega328 microcontroller and an MPU6050 sensor was being used to perform the onboard computations, while we will be using a flight controller based on a 32bit STM32F427 Cortex-M4F core with FPU microprocessor, which has higher processing power and will be used in conjunction with a single board computer. This system is proven to be more sufficient and reliable through the results obtained from the simulation. Furthermore, such a system allows the UAV not only to accomplish autonomous position control but also to allow for additional features such as computer vision for target detection and package delivery, while being light weight and cost effective.

4. HARDWARE

4.1 Assembly

Quadcopters have become a popular choice in UAV based projects as they have both structural integrity and stability. Hence, for the implementation of this project, a custom-built quadcopter was used. A fully enclosed carbon fiber frame was chosen for its durability and stability. Having an enclosed frame was essential for this project as it provides an additional safety layer. This frame was equipped with 2300KV brushless motors, which deliver enough thrust for the flight of the drone and Electronic Speed Controllers (ESCs) that provide enough electrical power to the motors based on the signal received from the flight controller. All the components used to build the drone are listed in Table 1.

TABLE 1: All Parts Used to Construct the Drone.

Part Type	Part Name	Description
Frame	Enclosed carbon fiber frame	Provide a base structure
Motor	2300kv ARRIS Motors	Provides thrust
ESC	Electronic Speed Controller	Controls the speed of the motors
Flight Controller	Pixhawk 1.2 cube	Sends RPM values to ESCs based on the data received
Rangefinder	TF-mini LiDAR	Measures the altitude
Optical Flow	PX4 Flow	Detects the change in ground features
Single Board Computer	Raspberry Pi 3.0	Perform on board computation
Power Distribution Board	PDB	Distributes power to the different components.

To allow all the electronic components to communicate, the flight controller Pixhawk 2.1 cube as seen in figure 1 was utilized. This flight controller was chosen for its advanced processor, a 32bit STM32F427 Cortex-M4F core with FPU microprocessor and sensor technology, a MPU9250 with 3 axis Accelerometer, 3 axis gyroscope and 3 axis magnetometer. The on-board computations were performed on the single board computer, Raspberry Pi 3 Model B (Figure 2), which features a quad-core 64-bit ARM Cortex A53 CPU. The Raspberry Pi is small, lightweight, and low-cost single board computer which has enough processing power to perform for the purpose of this project. To allow the drone to communicate with the transmitter, a receiver was also used. All these components were necessary to build a drone that would successfully accomplish autonomous navigation and position control.

Figure 1: Pixhawk Cube on Mini Carrier Board.

Figure 2: Raspberry Pi Model B

4.2 Sensors

The sensors play a vital role in determining the behavior of the drone and provide crucial information to predict its behavior. The major sensor used is the MPU9250 sensor embedded within the flight controller. MPU9250 is a 9-axis (3 axis accelerometer, 3 axis gyroscope and 3 axis magnetometer) motion processing unit or the inertial measurement unit (IMU).

Accelerometer technology has advanced so much that it is now reduced to integrated circuits measuring acceleration to the smallest degree. MEMS Technology stands for Micro-Electro-Mechanical Systems which aid in measuring the force a body experiences through a spring-mass system. The displacement caused by the force can be measured to calculate the magnitude of the force. MEMS technology uses this theory by measuring the distances between the capacitor

plates on a microscopic level. As seen in Figure 3, when the body experiences a force, the distance between the capacitors changes which can be used to calculate the force experienced by the body. By placing the system on each orthogonal plane, the complete force profile of the body can be measured.

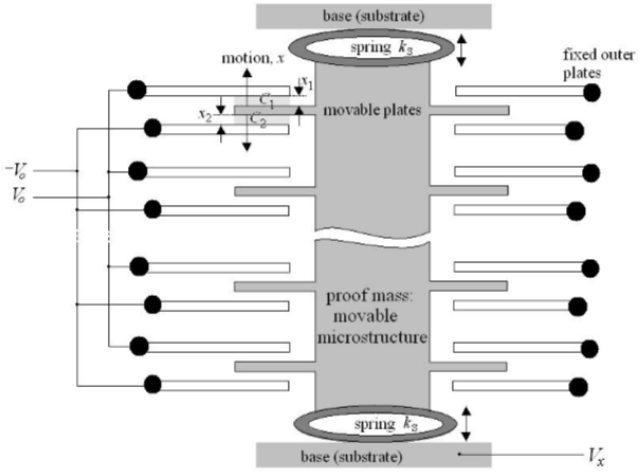

Figure 3: MEMS Accelerometer Diagram

The accelerometer measures the forces acting on the drone. One of the major forces the drone experiences is inertial force, which is due to the acceleration of the drone on all three axes. This acceleration value can be extracted from the accelerometer and can be used to predict the velocity and movement of the drone by separating the inertial forces on the drone. This concept is put into a mathematical equation, $d = a * t^2$ ('d' is distance, 'a' is acceleration and't' is sampling time), which can be used to get the distance of the drone in the 3 axes. Furthermore, the gyroscope on the sensor measures the rotation about the three axes. In other words, the gyroscope will measure the angular rate of change for the body and output a value that is linearly related to the rate of change of the angles. The data obtained from the accelerometer can be used in conjunction with gyroscope data to accurately estimate the inclination of the drone. The data acquired from the sensor was utilized in predicting the position change of the drone and this aided in counteracting that movement to allow the drone to actively measure the distance it travelled.

To achieve a stable flight, a rangefinder and an optical flow sensor was utilized. The TF-mini is a micro Light Detection and Ranging (LiDAR) rangefinder illuminates pulsed laser light and measures the altitude of the drone based on the time the laser takes to reflect to the sensor. The PX4 Flow optical flow sensor shown in figure 4 aided in accomplishing a 3D lock for the drone. The optical flow uses a downward facing camera to take images of the ground and detect the change in the features on the ground to allow the drone to maintain a specific position in 3D space. The data from these sensors was collectively used by the algorithm to send the correct throttle, roll, and pitch values to prevent the drone from changing altitude or drifting and successfully holding its position.

Figure 4: PX4Flow Optical Flow Sensor

5. SOFTWARE

5.1 Dronekit Python

Dronekit-Python [3] is an open-source software commonly used by developers aiming to investigate the autonomous boundaries of UAVs. Dronekit-Python is an API which provides an interface linking the vehicle and the user by providing a library which builds on MAVLink commands to control the drone. In this project Dronekit-Python aided in connecting to the drone as well as communicating with the drone. The "My Vehicle" class was used from Dronekit-Python which provided access to the various attributes of the flight controller, such as getting the vehicle status as well the data from the MPU9250 sensor embedded within Pixhawk.

Dronekit-Python also provides an interface which allows the user to set the mode of the vehicle. For this project, it was important for the vehicle to hold its altitude in order to perform stable flight. This was achieved by setting the vehicle in "altitude hold" mode; in this mode the vehicle can automatically control its altitude to hold the specified position in the z axis, while leaving the roll, pitch, and yaw to be controlled normally. Furthermore, the roll, pitch and yaw values were sent to the respective set channels specified through Dronekit Python in the algorithm to move the drone the desired distance. These channels were also modified when the drone was running the algorithm to achieve area hold. When the accelerometer in conjunction with the gyroscope predicts the movement of the drone based on acceleration, a counter pitch or roll value is sent to the Pixhawk to prevent the drone from drifting which allows it to hold its current position. Another major function provided by Dronekit Python is the landing function. When this function is called, the Pixhawk will receive the signal to gradually decrease the altitude of the drone to accomplish a smooth landing. This function was added to the algorithm to have the drone land smoothly once it has successfully accomplished its task.

5.2 Multithreading

Multithreading was used in order to control drift in the pitch and roll axes which allowed the drone to correct its position, simultaneously leading to stable hovering near its original position. The program used multithreading to execute multiple tasks concurrently which were beneficial in reducing some load off the main thread as well as carrying out multiple tasks. Multithreading on the single-board computer was supported through python which allowed for seamless integration

with the main thread. The threading module was used to create the pitch and roll corrections based on the estimated position of the quadcopter which were calculated through the accelerometer. The drone's velocity in each axis was experimentally calculated based on a constant controller values which would be used later to obtain the time for correction.

In each loop of the program, the acceleration values are obtained from the flight controller and double integrated to obtain the predicted distance the quadcopter will travel until the next loop. Next, the algorithm creates two separate threads for the CPU to handle the pitch and roll correction. The drone was given a set values of roll and pitch in testing to determine the velocity of the drone at those values. For example, at a value of 1450ms (PWM signal), the drone travels at a velocity of 1.2m/s. This measurement was obtained by using a slow-motion camera and 0.5m tags in the background to measure the velocity. The distance predicted by the algorithm is then divided by the set velocity to determine the time for the correction loop. As seen in figure 5, the program manages the pitch and roll control corrections independently by directly getting the accelerometer data. The program creates a task for the SBC which ran timed loops that counteract the estimated position based on the current acceleration of the drone. The drone applied the opposite action to the estimated position, i.e., if the drone was expected to move forward, the program would send pitch backward values to the drone for the determined amount of time.

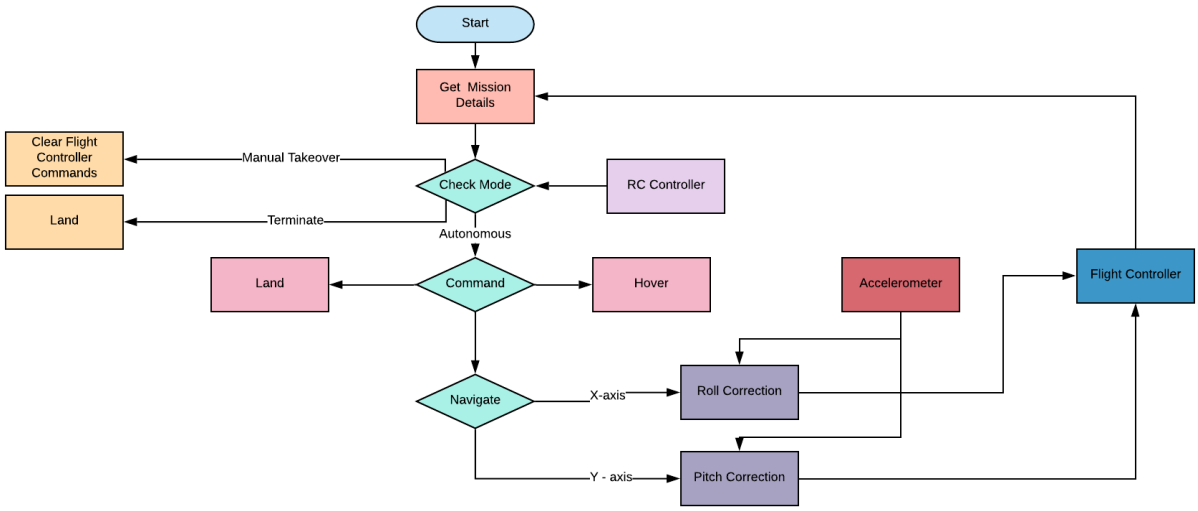

Figure 5: Basic Flow Chart of Program Logic

This approach was used in getting the drone to correct the drift in the x and y-axis to achieve "area hold". Since the accelerometer introduced large errors and is an inaccurate sensor in obtaining position information, this methodology was used in maintaining a position that was in a $1m^2$ circular area. Additionally, multithreading was used in removing drift when the drone was moving in a specific direction. For example, when moving in the x-axis was the forward and backward direction, only the roll was corrected and vice-versa.

5.3 Software-In-the-Loop (SITL) Testing

Since the methodology was experimental, the program was first tested in a simulated environment, as seen in figure 6 which modeled the drone and how it would behave in real life. Ardupilot SITL is a powerful tool used to simulate a quadcopter as it has the physics engine pre-

configured for various styles of drones such as planes, rovers, and multi-rotors. As seen in Figure 7, the SITL comes with different preset options available to the user. However, Ardupilot SITL is only a terminal simulator, meaning it does not provide a graphical user interface. On the contrary, Gazebo is a graphical simulator environment which supports a wide variety of tools and interfaces for rapid prototyping. The environment was used to provide a graphical representation of the drone and how it would operate in an indoor environment in real life. MAVProxy, which is a lightweight Ground Station Software for Unmanned Aerial Vehicles that operate on MAVLink systems was used to connect Ardupilot SITL to Gazebo.

The gazebo simulation environment was used as an add-on to the UDP 14450 port made available through MAVProxy. The simulated drone had to be modified in order to successfully replicate the indoor environment. A rangefinder was added to the simulation in order to provide consistent simulated altitude, as the barometer present in the real world as well as in the simulated one has a lot of noise in the readings. Additionally, the GPS was disabled as there will be no GPS available for indoor navigation.

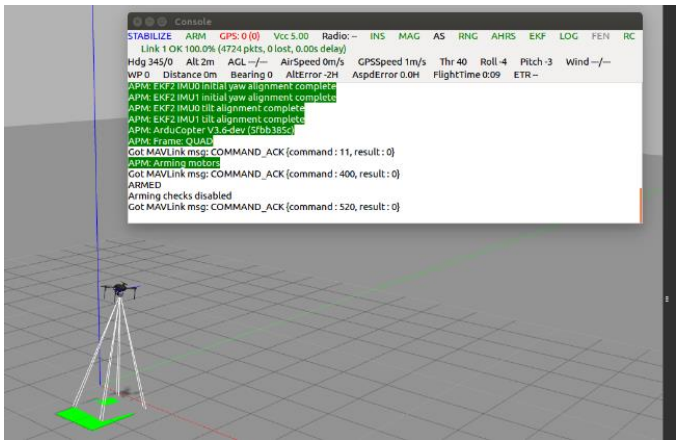

Figure 6: Drone Navigating in Simulated Environment

During the testing phase, the core programming methodology was developed which utilized multithreading for area hold of the drone. SITL yielded meaningful results in which the drone held the position in a 1 m^2 area for approximately 15s before starting to drift. SITL allowed the researchers to test the code in a controlled environment without any hardware expenses and SITL was closely accurate to the real world. The drone successfully travelled 5m in the simulation.

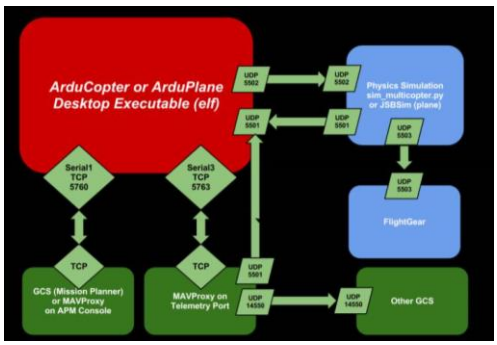

Fig. 7: Simulator Environment Setup

6. SAFETY

The drone was tested in a netted area without any constraints such as added strings to control unpredictable crashes. The netting also allowed the researchers to test in worst-case scenarios such as transmitter loss. Since the drone was navigating indoors, it was imperative to have a human operator on standby to take over and terminate the code if the drone did not function properly. A three-part fail-safe system was implemented in the event of a malfunction which would minimize damage to the drone as well as its surroundings. The fail-safe includes emergency land, manual takeover, and kill switch.

The emergency land is designed to immediately land the quadcopter by changing the vehicle mode to the preset Land function available in Dronekit-Python. Additionally, the algorithm is terminated in order to avoid further navigation, and the drone must be re-started and recalibrated for safety before another flight. A manual takeover of the drone was designed through programming a switch on the paired transmitter which would put the code on hold and let the operator takeover the quadcopter navigation in an event when an emergency land is not operable. As a last case precaution, the quadcopter utilized a feature in the flight-controller which shuts off all the motors, effectively stopping the drone from creating disruptions in the surrounding environment.

7. IMPLEMENTATION

After the algorithm was simulated, the real-world counterpart was developed with an error factor correction. Since an accelerometer is a low-accuracy sensor, the distance measured has an inherent error during the double integration process of the algorithm. Researchers found the error factor through experimentation which resulted in consistent target distance travelled. The error factor is the percentage of the estimated distance travelled by the drone in relation to the actual distance travelled. The target distance that the drone needed to travel was 10m and the drone's estimated distance was compared to that value. For example, as seen in table 2, an error factor of 1 resulted in the drone travelling only 3.7m. This shows that the drone estimated the actual distance travelled (10m) to be 25m due to errors in integration. Researchers used this as a scale in finding an error factor which multiplies the actual distance by a factor of 2.5 which yielded estimated distance travelled to be comparable to the actual distance travelled.

TABLE 2: Error Factor Selection

Error Factor	Actual Distance Travelled (m)
1	3.7
1.5	6.8
2	8.2
2.5	9.4

8. RESULTS

The algorithm successfully measured the amount of distance travelled by the quadcopter. Numerous tests were conducted, some of which are tabulated in table 3, where the quadcopter travelled 10m. The algorithm consistently measured the distance travelled by the drone to be

within 4% range of 10m with values ranging from 9.6m to 10.4m. This shows that the tests were successful in using the accelerometer for distance measurement. The algorithm can be used for indoor navigation as a low-level localization tool since the distances were accurate.

TABLE 3: The actual distance travelled by the drone and the calculated error between the desired distance actual distance travelled.

Trial	Distance Travelled (Meters)	% Error
1	9.84	1.6%
2	10.33	3.3%
3	10.25	2.5%
4	9.91	0.9%
5	10.14	1.4%

The drone was additionally able to hold the position for 6s before drifting outside a 1m box. This is less than the time predicted through the simulation and is most likely due to additional vibrations in the real-world drone compared to the simulated drone. The algorithm for area hold was successful in transitioning from area hold to a forward flight path. This shows that the algorithm can be used for path planning purposes in indoor navigation.

The algorithm was also successful in correcting the drift of the drone when it is travelling on a certain axis. When the drone traveled forward, the roll axis drift was corrected based on the acceleration on the y-axis. Similarly, when the drone travelled in the y-axis, the drift in the pitch axis was corrected based on the acceleration in the x-axis, which lead to better autonomous navigational control for the drone as the drone was able to travel the desired path without drifting significantly.

9. CONCLUSION

The IMU unit can be effectively used to measure the distance the UAV has traveled in the x-y plane. The algorithm developed to measure the distance the drone travelled has been proven to be both consistent and accurate. The data obtained through this algorithm proves that it is possible to accomplish different tasks such as having the drone follow a certain path autonomously or hold its position in 3D space. This algorithm can be used as the basis for further development.

The developed algorithm will serve the user as a base to build upon. For instance, if the user intends to build an autonomous drone that is both light-weight and cost-effective to perform image processing, the user can use the algorithm to achieve a stable position control of the drone indoors autonomously without the need of heavy expensive sensors, since the user need only add a camera along with the script for image processing. The use of this algorithm will give the user the freedom to add more operational layers to the drone such as target detection systems, delivery systems, and position-hold.

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3D Printed Brain-Controlled Robotic Prosthetic Arm

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ABSTRACT

Today, there are many prosthetic options for amputees ranging from purely aesthetic to fully functioning myoelectric limbs. However, these options are not always viable due to high cost, invasive surgery, and long rehabilitation time. This paper describes the design and development of a robotic arm controlled by electroencephalography (EEG) signals from the user's brain. This project crosses into the fields of biomedical, mechanical, and mechatronic engineering and aims to prove that a brain-controlled 3D-printed prosthetic is more affordable and non-invasive. The robotic arm prototype is intended to aid upper limb amputees with their regular everyday functions using a range of short below elbow (BE) to wrist disarticulation (WD). Therefore, the design includes not only a hand but also a forearm helping to build upon the residual limb. Additionally, the design of the mechatronic system minimizes the rehabilitation required on the amputee's part. During preliminary research and testing, brain signals were successfully measured and recorded using an Emotiv Insight EEG headset. The Emotiv Xavier Control Panel and EmoKey software enabled a user to successfully command servo movement using signals from the brain. These servos then create movement in the prosthetic. Future work on this project will result in a fully functioning prototype.

1. INTRODUCTION

One in every two hundred people is an amputee in the United States [1]. There are many prosthetics available today with a range of advantages and limitations. For example, cosmetic prosthetics are primarily for aesthetic purposes but can also be used for balance. Cosmetic prosthetics date to as far back as 950 BC to 710 BC when a wooden prosthetic toe was discovered in the on an Egyptian mummy. The cost and rehabilitation time associated with this option are comparatively low as seen in Table 1. In the 1860s, during the American Civil War, over 70,000 soldiers had a limb amputated [2]. As a result, prosthetics saw further development, and mechanical functions were added by using straps attached to the amputee's body [3]. Mechanical arms offer some

functionality but are limited and require extensive rehabilitation time. The robotic arm prototype, however, requires little to no invasive surgery and is often detachable.

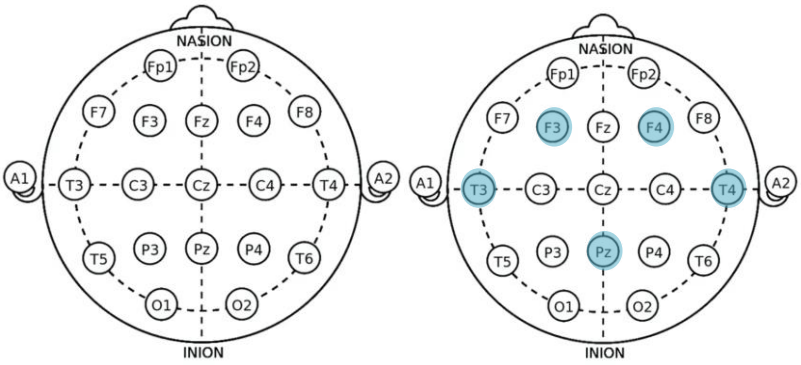
Table 1. Comparison of Available Prosthetic Devices

	Cosmetic	Mechanical	Myoelectric
Cost	< $5,000	< $10,000	$10,000 - $20,000
Invasiveness	None	Minimal	Minimal
Rehabilitation	6-12 months	12+ months	12+ months
Functionality	Passive	Basic movements	Many grip patterns

In 1948, a Munich University physics student, Reinhold Reiter integrated myoelectric technology into prosthetics in order to offer more functionality to upper limb amputees. Electromyography (EMG) sensors were used to measure the electrical signals of muscles in the residual limb, and the signals were used to control motors on the prosthetic [4]. The Bebionic myoelectric hand is the most sophisticated myoelectric hand available today, featuring different hand sizes and wrists, fourteen grip patterns, opposed and unopposed thumb positions, and grip-enhancing soft finger pads. The Bebionic hook grip can carry up to a 45 kg load, and each finger can hold up to 25 kg. The price of a Bebionic hand starts at about $11,000 including only the hand. If an arm is needed along with the hand, additional costs, surgery, and rehabilitation are added [5]. For successful use of a myoelectric prosthetic, muscles in the residual limb must produce the minimum microvolt threshold required to receive the electric signal from the muscle [6]. Further, the amputee must be able to control the amplitude of the signal to proportionally control the speed and grip force of the machine [7]. Though they provide much functionality, myoelectric prosthetics are expensive and control is limited.

Neurons throughout the body use electrical signals to transmit and receive information to each other using synapses [9]. The brain contains about 100 billion neurons [10] which emit a synapse 0.1 - 2 times per second [11]. Measuring differences in electrical charges between electrodes is called electroencephalography (EEG). These signals are very small, measuring in tens of millivolts; therefore, the signal must be amplified [9]. The brain is made up of four main lobes: frontal, temporal, parietal, and occipital. The frontal lobe is responsible for reasoning, motor skills, higher level cognition, and expressive language. The temporal lobe is responsible for sensory information processing such as hearing. The parietal lobe processes sensory information such as touch, pain and pressure. Information processing for vision occurs in the occipital lobe [12].

The International Federation of Clinical Neurophysiology developed the International 10-20 electrode placement standard for EEG testing (Figure 1). It is called the 10-20 system, because each electrode is placed either 10% or 20% apart. The first letter of the electrode represents the brain lobe in which it is located. The numbers indicate in which hemisphere of the brain the electrode is located- odd numbers for the left and even numbers for the right hemispheres [13]. Figure 2 shows the sensor positions, highlighted in blue, that are used in this project. The parts of the brain that control hand motion can be detected at three points F3, F4 and T4.



Figures 1 and 2. The International 10-20 Electrode Placement Standard

2. OBJECTIVE

The objective of this project is to design a prosthetic hand that can open and close and include rotation of the wrist using EEG signals from the brain.

3. SYSTEM ARCHITECTURE

The design of this prosthetic is a combination of components from mechanical, electrical and software engineering, otherwise known as Mechatronic Engineering. The prosthetic hand is designed to replicate the motion of the human hand and to resemble it as closely as possible. The hand is designed using stereolithography (SLA) and polylactic acid (PLA) apparatus 3D printing material. The fingers on the hand are controlled by artificial tendons made of 80 lb braided nylon line. The tendons are connected to servo motors and both work together to create motion in the fingers. High-torque servos are used to generate a force of around 600 N to achieve the max grip strength recorded in an adult male [15] and a durable design for this load. This level can be adjusted in the future depending on the user; for example, the force could be reduced to match a child's grip strength. With the current motors, the design should hold at least 13 kg of weight. Figure 3 shows an overview of the system. To control the servos, the Arduino Uno R3 is used with an Adafruit servo shield. The Arduino Uno receives input signals from Emotiv Xavier Control Panel and Xavier Emokey software. The Emotiv Xavier Control Panel enables the user to train mental commands with the EEG headset, and the Xavier Emokey software sends pre-defined keystrokes that represent mental commands to the Arduino IDE as input. The input keystroke determines which position the servos move to and effectively changes the position of the robotic hand. A raspberry is intended to run the software and process the information; although, until it is developed, a laptop is used for this task. The headset is the Emotiv Insight which has five EEG sensors and communicates with the computer via low energy Bluetooth (BTLE). They detect the brain waves by detecting the electrical signals produced by the neurons. This is how the system knows a mental command is being sent to control the hand.

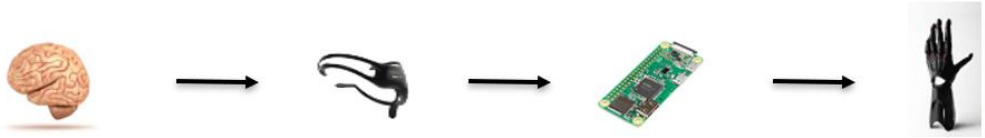


Figure 3. System Overview

3.1. MECHANICAL DESIGN

The material chosen for this project is SLA tough resin 3D printing material. Tough resin was developed for applications with high stress and strain. Parts printed in tough resin have a tensile strength and a modulus of elasticity comparable to Acrylonitrile Butadiene Styrene (ABS) 3D printing material (see Table 2). This SLA material is not food safe; however, to solve this problem a polyurethane coating will be added to the finished product, once it has cured for thirty days. SLA is widely used in the prosthetic field, because it creates very fine details with a smooth finish and easily scales, making it adaptable to many different arm sizes, as in the case of a growing child. As the child grows, the same design could be printed in different sizes. However, one disadvantage of this material is that it is relatively expensive. Due to time and material restrictions, not all the prototype's parts were printed in SLA. The hand of the prototype was printed in SLA, but other parts of the prototype were printed using Polylactic Acid (PLA), a material with a much lower tensile strength (37 MPa) making it weaker than SLA. In future work, the forearm and wrist will be redesigned and modified to accommodate a residual limb and a socket for attaching to the amputee. The goal is to create an affordable design which is durable and strong; therefore, all of the parts will be printed in SLA.

3.2 HAND

The design for the hand was adopted from an open-source website called imoov.com. This design was chosen to achieve a curved grip when closing the fingers, ideal for gripping round objects. Its components consist of the palm, and thumb, index, middle, ring and pinky fingers. The palm was printed as one part, while each finger was printed in six parts and then assembled using epoxy. For the joints, 3mm ABS filament strands were used to complete the finger. Each joint rotates 90 degrees to one another for the closed position. Figure 4 shows the design of the hand.

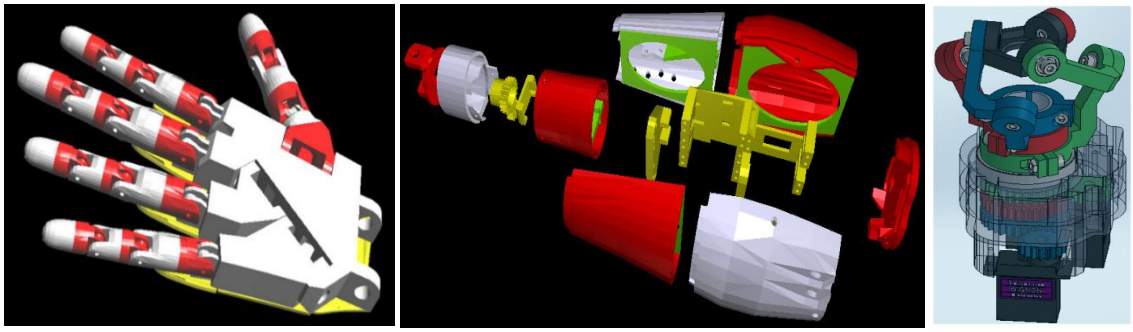
3.2.1 FOREARM

The forearm was also adopted from thingiverse.com, another open-source website. The forearm in this design was used to achieve a working prototype as quickly as possible. The servos were attached to this part of the prototype and connected to the fingers by the tendons. All the components were assembled using #6 half inch screws. This part of the design is not final as it is bulky and would hinder the use of a socket for attaching to the residual limb. Future work on this design includes solving this problem and reducing the size and weight. The new design would also accommodate more servos to add further motion in the hand. Figure 5 shows the forearm currently used for the prototype.

3.2.2 WRIST

The wrist used for the prototype was chosen to achieve rotational and gliding motion of the hand. Gliding motion would be developed in phase two, once rotation is achieved. The design was also sourced from thing thingiverse.com. It is called the Parloma wrist (see Figure 6) and is intended to have greater flexibility in the positioning of the actuators and consequently greater freedom in

the design. The wrist was assembled using #6 half inch bolts and then attached to the arm using epoxy resin.



Figures 4, 5 and 6. Hand, Forearm and Wrist CAD Assembly.

Table 2. ASTM standards and material properties for SLA tough resin [17]

Measurement	Condition	Metric
Tensile Strength	ASTM D 638	63 - 68 MPa
Tensile Modulus	ASTM D 638	3,200 - 3,380 MPa
Elongation at Break (%)	ASTM D 638	5 - 8 %
Flexural Strength	ASTM D 790	88 - 110 MPa
Flexural Modulus	ASTM D 790	2,690 - 3,240 MPa
Impact Strength (Notched Izod)	ASTM D 256	12 - 22 J/m
Impact Strength (Notched Izod)	ASTM D 5420	1.1 J
Heat Deflection Temperature	ASTM D 648 @ 66 PSI @ 264 PSI	 55 - 58 °C 51 - 53 °C
Hardness, Shore D		85

3.3 Electrical Design

The electrical design of the project is combined to the mechanical part by the servos and tendons. This project uses four servos, three for movement of the fingers, and one for the rotational movement of the wrist. Three servos are attached to the tendons, and then the tendons are attached to the fingers. They work together to create movement and enough force to grip an object. The servo rotation dictates the movement in the hand, and the servos are controlled by the servo shield interfaced with a microcontroller. The shield receives the commands from a Raspberry Pi, and a rechargeable lithium ion battery is used to power the whole system. A laptop is currently doing both tasks, with the aid of four AA batteries to power the servos.

3.3.1 SERVO MOTORS AND TENDONS

The servos used are high torque servos with 140° range of rotation. These servos were chosen to achieve the grip force an adult male. The maximum human grip strength recorded is around 600 N [16]. These servos are rated to produce a stall torque of 13 kg-cm at 4.8 V. They have an operating speed of 0.17 seconds / 60° with no applied load when supplied with 4.8 V. Using the illustration in Figure 7 and equations for torque (1) and momentum (2),

$$\boldsymbol{T = F \times r \times sin\theta} \tag{1}$$

where:
T = Torque (Nm)
F = Force (N)
r = Radius or Perpendicular Distance (m)
θ = Angle between r and F

$$\boldsymbol{M = F \times \perp d} \tag{2}$$

where:
M = Moment (Nm)
F = Force (N)
⊥ d = Radius or Perpendicular Distance (m)

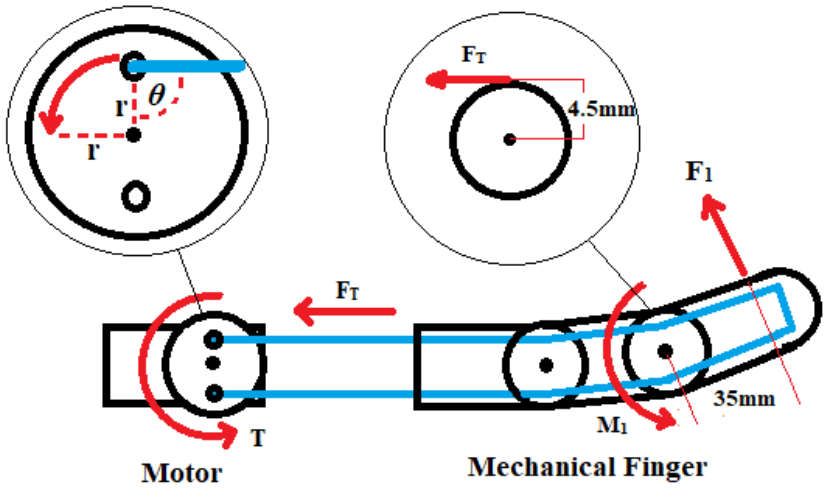


Figure 7. Illustration for Torque Calculation

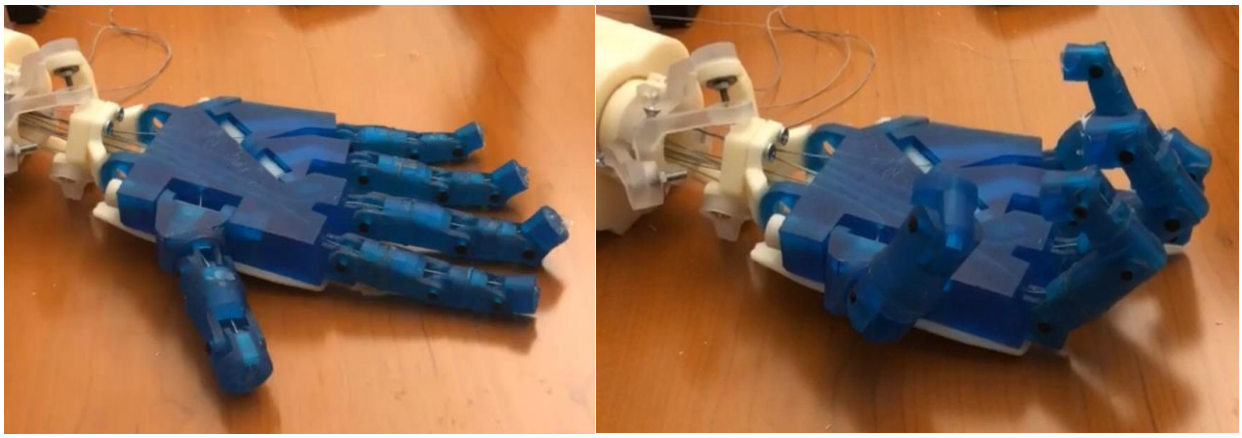
assume $\theta = 90°$ for the finger at open position, τ = 13 kg-cm = 1.275 N-m and $r = 0.0135\ m$. As the motor turns, θ becomes smaller and F_T is expected to increase when applying grip to an object. For example, the servo turns a rotational distance of 89°, almost max position. This means $\theta = 1°$ therefore according to equation 1, F_T = 5411 N. This tension then generates the moment M_1 which in turn generates the force F_1. According to equation 2 and the perpendicular distance 4.5 mm, M_1 = 23.8 Nm. Using equation 2 again, M_1 = 23.8 Nm and perpendicular distance 35 mm, the force F_1 generated is 680N. From the current design, the motors satisfy the target grip strength intended

and proves the selection a success. An 80 lb braided nylon line is used to transfer the tension between the motor and the finger. This line can withstand a range from 355 N to 400 N before failing and was chosen to develop the prototype. However, for future use a 160lb line can be incorporated and should withstand at least 700 N before failing. According to these calculations, the maximum force that a finger grip can produce is around 680 N. This means that a finger will experience a reaction equal to this force. Using equation (3) and the surface area of the finger experiencing this stress of 0.00175m^2, the working stress is 0.389 MPa. According to Table 2 ultimate stress is 63MPa, therefore using equation (4) the factor of safety is very high (FS = 161) and the part will safely support exerted load.

$$\boldsymbol{\sigma = \frac{F}{A}} \tag{3}$$

where:
σ = *Stress (MPa)*
F = Force (N)
A = Area (m^2)

$$\boldsymbol{Factor\ of\ Safety = \frac{\sigma_{ultimate}}{\sigma_{applied.}} = \frac{63}{0.4} = 161} \tag{4}$$



Figures 8 and 9. Open (Left) and Closed (Right) Positions of the Prosthetic Hand

3.3.2 ELECTRICAL CIRCUIT

The electrical schematic of the system is depicted in Figure 10. As mentioned before, once programming is complete a Raspberry Pi B 3+ will be implemented, while currently the Arduino receives the mental commands and power from a laptop and the servos are powered by four AA batteries.

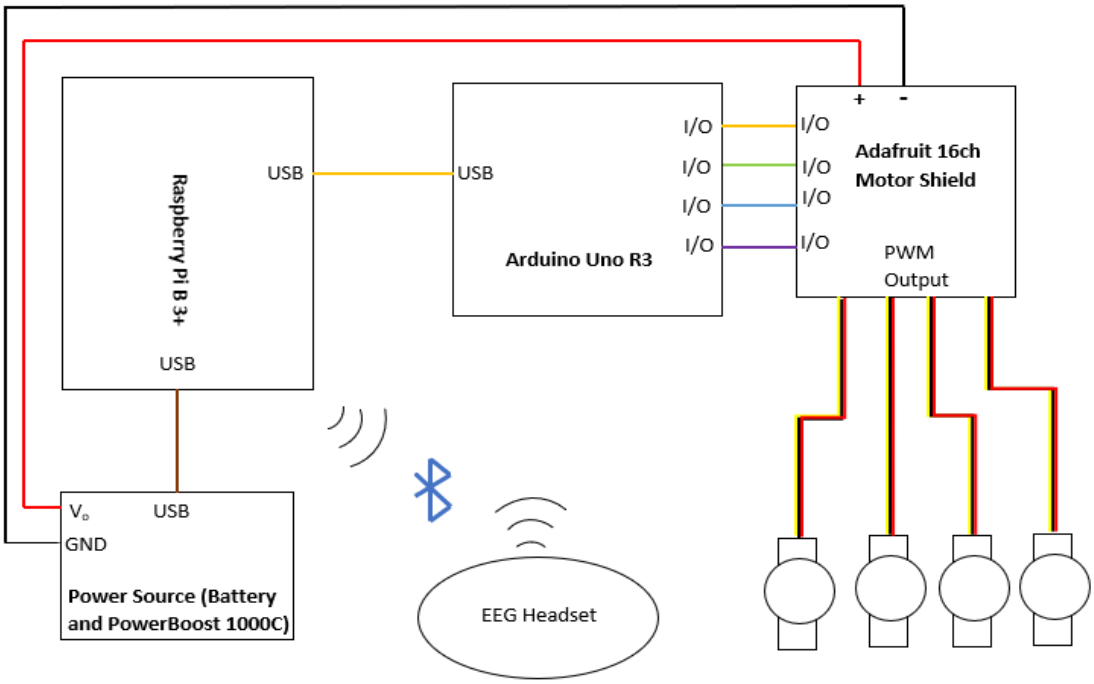


Figure 10. Electrical Schematic of the System

3.3.3 Microcontroller and Servo Shield

The microcontroller used to control the servos is the Arduino Uno stacked with an Adafruit Servo Shield. The Arduino Uno has a 16 MHz processing time and is easily programmable. The Adafruit Servo Shield uses pulse width modulation (PWM) to mimic analog signals using digital signal, allowing the servo shield to control the position of the servos. Another important role of the Adafruit Servo Shield is to protect the Arduino from any flow of high current and voltage used by the servos. It also provides an easy way to prototype with sensors and servos. Also, the Adafruit Servo Shield minimizes space usage because it does not need extra wires to power the servo and sensors. As mentioned before, the system currently relies on a computer or laptop to receive the data, then filter and process it. Once programmed, a Raspberry Pi B 3+ will make the system portable. This microcomputer has a 1.0 GHz CPU and 512 MB RAM. Since the sample rate of the Insight is around 128 Hz which is 128 samples/sec or bits/sec per sensor. This means 128 bits/sec $\times$ 5 sensors = 640 bits/sec being received by the processor. Therefore, the processor is more than capable to process the 640 Hz of data received.

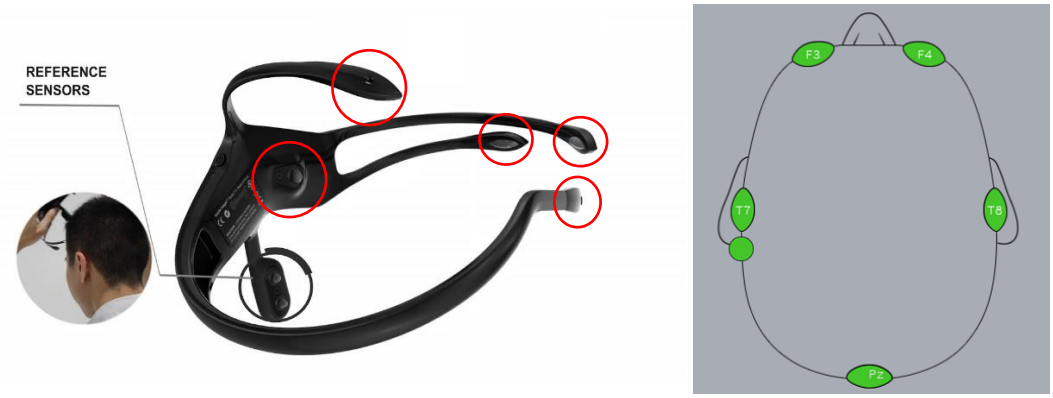
3.3.4 Power Supply and Power Booster

The power supply and booster used are by Adafruit. The battery used is the Adafruit Li Ion 3.7 V 6600 mAh and the power booster is the Adafruit PowerBoost 1000C recharger. This booster allows the battery to be recharged safely even while in operation. The Arduino is currently powered by the laptop, and the motors are currently powered by four AA batteries. The Raspberry Pi consumes approximately 350 mA at idle and 980 mA at 400% max CPU load, making an average of 665 mA. Also 45 mA for the Arduino and around 90mA per motor for the four motors. The total

average power consumption comes up to 1070 mA. Therefore, with the current battery capacity the system has approximately six hours of battery life. The 1000C has a maximum output of 5 V and 1 A used to boost the battery power from 3.7 V to the 5 V, the requirement to power the microcontrollers and the servos. This is also the required voltage to obtain the 13 kg-cm torque rating of the servos.

3.4 COMMUNICATION

For communication between the brain and the prosthetic, this project uses the Emotiv Insight EEG headset. The Insight has five sensors as shown in Figure 11, and the position of these sensors is shown in Figure 12. These sensors work together with the reference sensors to detect brain waves through the detection of differences in the small voltages produced by the neurons. These voltages are amplified and then recorded over time in microvolts by the software. Each microvolt is sent from the headset as one sample. The headset can send 128 samples per second and uses Bluetooth Low Energy for communication sending signals to the laptop via a Bluetooth LE USB receiver. The Arduino Uno receives the input from the computer, and finally, interfaced with the Adafruit Servo Shield controls the servo motors. This Bluetooth is a low-energy and automatic wireless connection that transmits information through radio waves [16]. Bluetooth Low Energy (BLE) uses seventy-five percent less energy than popular Bluetooth 4.0 [16], thus minimizing power consumption and avoiding a large battery, since the prosthetic has limited space. Additionally, it is wireless to maximize comfort and convenience.

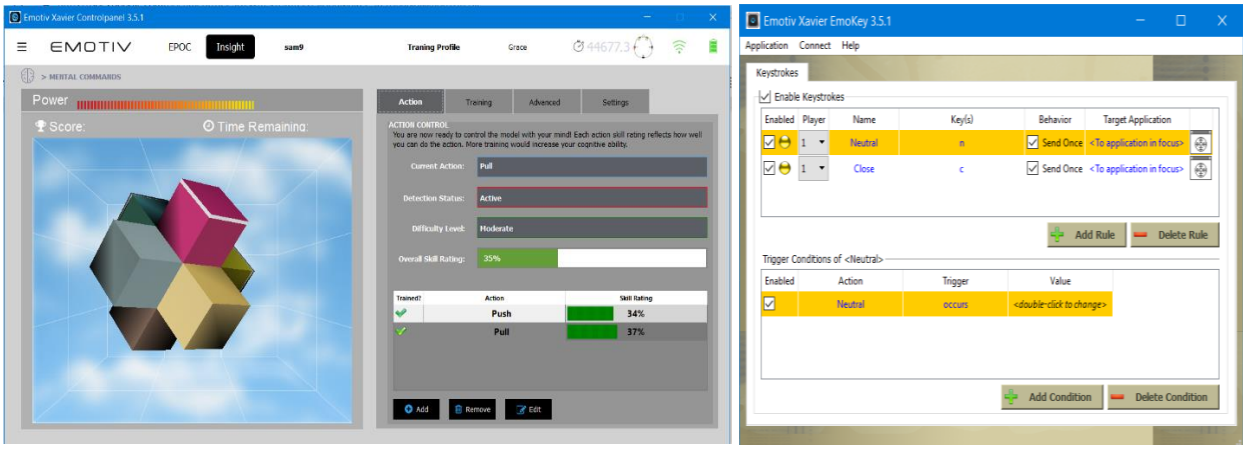


Figures 11 and 12. Xavier Control Panel

3.5 SOFTWARE DESIGN

3.5.1 SIGNAL PROCESSING

The Emotiv Insight communicates with Emotiv Brain Computer Interface software known as Emotiv Xavier Control Panel (see Figure 13). The software filters out noise and records the amplified signals. Once the headset is adjusted and the signal is strong, users are prompted to train their neutral state as the reference point. Once this is done, other states such as push, pull and rotate are then trained in comparison to one another. These states are then interpreted as the mental commands by the Emotiv Xavier EmoKey (see Figure 14) and mapped to keystrokes as outputs. These keystrokes are then interpreted by the Arduino IDE and perform the desired actions. This is how the software calibrates the EEG headset to control the prosthetic.



Figures 13 and 14. Xavier Control Panel and EmoKey Keystroke Conditions

3.5.2 XAVIER CONTROL PANEL

Xavier Control Panel (Figure 13) is the user's main interface when controlling the prosthetic arm. The software monitors the signal strength of each sensor and allows the headset to be calibrated by training various mental commands. First, a neutral state must be trained by relaxing the mind. Once this recorded, the other states can then be trained. During the training sessions, instead of focusing on the cube's movement, a movement relevant to this application, such as closing the hand, is trained. After each session, the Xavier Control Panel will produce a warning if poor training was detected, or an indication of success if a good signal was received. It is recommended to train at least twice for each state to ensure a good reading. The software also calculates the user's skill rating, which is a necessary tool for effectively training the headset.

3.5.3 XAVIER EMOKEY

Once training is complete, the Xavier EmoKey software (Figure 14) receives mental commands from the Xavier Control Panel. A set of rules are defined to map a mental command with a specific keystroke. For instance, when Xavier EmoKey receives a "pull" command from the Xavier Control Panel, the software is prompted to output the keystroke "c". This output can be set to a specific program, for example Notepad, to produce the letter. In this project, Arduino IDE is set to produce the action of closing the fingers. The software also has an indicator light to show the user which mental command is being received from the headset. Additionally, the threshold for each mental command can be adjusted manually to calibrate the system to the individual user.

3.6 ARDUINO UNO

The Arduino Integrated Development Environment (IDE) is an open-source and easy to use IDE for programming the microcontroller. The Adafruit Servo Shield uses a special library called the Adafruit PWM Servo Driver library and enables the pulse width to be adjusted. As shown in Figure 15, the program automatically executes the following processes, addresses the servo shield, calibrates the servos, opens a serial connection, sets the frequency, and converts degrees into pulse width (Figure 15). Additionally, an infinite loop of if-statements controls the position of the servos if the keystroke inputted to the Serial Monitor satisfies the condition (Figure 16).

servoControl §

```
#include <Wire.h>
#include <Adafruit_PWMServoDriver.h>
Adafruit_PWMServoDriver pwm = Adafruit_PWMServoDriver();// Default address 0x40
#define MIN_PULSE_WIDTH       650   // Set servo min to 650 out of 4096
#define MAX_PULSE_WIDTH       2350  // Set servo max to 2350 out of 4096
char mentalCommand;  // Create char variable

void setup() {
  Serial.begin(9600); // Open serial communication
  pwm.begin();
  pwm.setPWMFreq(60);  // Analog servos run at ~60 Hz updates
}

int pulseWidth(int angle){ // Convert degrees to pulse width
  int pulse_wide, analog_value; // Create int variables
  pulse_wide   = map(angle, 0, 180, MIN_PULSE_WIDTH, MAX_PULSE_WIDTH); // Map
  analog_value = int(float(pulse_wide) / 1000000 * 60 * 4096);
  return analog_value;
}
```

Figure 15. Initializing the Adafruit Servo Shield

```
void loop() {
  if (Serial.available() > 0) // Is a character available?
   {mentalCommand = Serial.read(); // Get the character
    if (mentalCommand == 'c') // If close command
      {pwm.setPWM(0, 0, pulseWidth(0)); // Go to closed position
       pwm.setPWM(1, 0, pulseWidth(0));
       pwm.setPWM(2, 0, pulseWidth(0));
       pwm.setPWM(3, 0, pulseWidth(0));
       Serial.println("Closed");
      }
      else if(mentalCommand == 'n') // If neutral command
      {pwm.setPWM(0, 0, pulseWidth(90)); // Go to neutral position
       pwm.setPWM(1, 0, pulseWidth(90));
       pwm.setPWM(2, 0, pulseWidth(90));
       pwm.setPWM(3, 0, pulseWidth(90));
       Serial.println("Open");
      }
    }
}
```

Figure 16. Servo Control using If-Statements

4. FUTURE WORK

During the first phase, the movements achieved are the basic opening and closing of the fingers, turning of the wrist, and gripping of an object. So far, the system is capable of only opening and closing the fingers. Additional programming will enable the system to perform more motions. A major disadvantage of this system is that it is not portable or automatic. A code is currently being developed to accomplish this with a Raspberry Pi. The Raspberry Pi can also communicate with the Emotiv Insight via Bluetooth Low Energy. When the Raspberry Pi is interfaced with the Arduino Uno, the two will share the processing load to avoid delay or overload in the system. Another major drawback of the arm is that it does not have a socket to attach to a residual limb;

therefore, it cannot be used as a prosthetic. A new design of the forearm is currently being developed to include a socket and to minimize weight.

The second phase includes the ability to complete some additional everyday household tasks such as eating and drinking, brushing teeth, turning on and off light switches, and turning keys. The wrist design has been modified by Parloma to have many more degrees of freedom, allowing for movement for sign language (Figure 6). More motors will be added to create the movement and allow for an advanced range of motion for everyday tasks. Once these are completed, the purpose of the third phase is to protect the prosthetic by implementing sensors. Temperature sensors will provide feedback not only for the user's safety, but also to let the user know this temperature is dangerous to the device. Additionally, the arm will be waterproof to protect the electronics. Wet and dry sensitive skin covering the arm will notify the user of the wetness or dryness of an object..

5. CONCLUSION

Through our research, it is evident that currently available prosthetics have serious limitations due to their expense, invasiveness, and long rehabilitation times. Additionally, those afflicted by paralysis or shoulder disarticulation require an option that does not rely on EMG signals. By harnessing brain waves in the form of EEG signals and integrating them into a brain computer interface, the ability to control a robotic arm will become available to amputees and other patients. Throughout the length of this project, attention will be directed to the completion of all three phases ,while maintaining a low cost in the creation of a high-fidelity prosthetic arm. The first prototype implemented EEG signals to control the prosthetic arm and cost less than $700 making it affordable for low-income and quickly growing pediatric patients. In addition, the robotic arm is environment-friendly, food safe, and energy-efficient.

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Walking Wise Camera Sensor Smart Cane

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Abstract

The goal of this project is to engineer a modernized hand-held device outfitted with advanced input sensors and a revolutionized feedback system that will change the way the visually impaired traverse their environment. According to the World Health Organization (WHO), there are approximately 285 million individuals around the world currently living with partial or total blindness. These visually impaired individuals face numerous obstacles which they must overcome as they go about their lives, and mobility is one of their most difficult and dangerous challenges. This smart cane, named Walking Wise, will combine the functionalities of a camera sensor and image recognition software as well as an ultrasonic sensor to detect obstacles in the user's immediate surroundings and return measured information via mixed feedback system consisting of speakers and vibrating motors. Walking Wise is designed to be portable, environmentally friendly, and cost efficient to ensure this product can impact as many lives as possible. To test the functionality of this device, a volunteer is placed in an unknown and controlled environment with a Walking Wise prototype. The controlled environment contains various obstacles that fall into this area of interest. If the volunteer can navigate the course blindfolded, the goal is achieved, and the project is successful.

1.0 Introduction

According to World Health Organization (WHO), there are approximately 285 million individuals globally who suffer from visual impairment, with 39 million being completely blind [1]. This growing population relies on outdated technology (see Fig. 1) to provide mobility in today's world. The probing cane is nothing more than a collapsible rod that provides no output other than improving the range of the user's sense of touch. The blind rely on others around them to assist in their navigation of crosswalks and traffic lights. The probing cane is unable to detect the presence of low hanging objects. Branches, fire escapes and low ceilings obstruct the forward path without a ground contact point. Consequently, the probing cane is unable to help the user detect these objects. This issue creates a need for an improved probing cane, capable of detecting obstacles and environmental changes regardless of the presence of a ground touch point. A cane equipped with

innovative sensors will be able to detect oncoming obstacles and inform the user. Furthermore, the sensors can detect the different outputs of crosswalk signals, allowing independence when crossing intersections thus providing increased mobility for the user.

Figure 1. Probing Cane

1.1 Objective

The objective of this project is to create an easy-to-use device, capable of detecting a wide range of obstacles in order to improve the mobility of the visually impaired community. The probing cane is outfitted with an onboard camera sensor and ultrasonic sensor which detect environmental changes and obstacles around the user. Using data gathered from the camera and ultrasonic sensors, a feedback system relays the presence of obstacles and their nature. The device is user-friendly to accommodate all ages, with controls for feedback intensity. Finally, the device will be collapsible, lightweight and rechargeable to improve portability.

1.2 Background Research

As they travel, the visually impaired community relies on a variety of sources for aid. Recently, particular researchers and companies have begun working to improve the probing cane. The reoccurring trend is to incorporate ultrasonic sensors into the probing cane in one of two manners. The first innovation is an add-on device that attaches to a probing cane in order to add sensors to existing canes. One of the most popular versions is the SmartCane model, developed by IIT Delhi, Saksham and Phoenix Medical Systems, featuring two ultrasonic sensors which detect objects that lack ground touch points [2]. The lower sensor detects low hanging objects at knee height while the upper sensor detects objects from knee height to head height. The second innovation is a custom-built probing cane featuring ultrasonic sensors and a feedback system. The most prominent example is the UltraCane created by a company of the same name [3]. Like the SmartCane, the UltraCane has two built in ultrasonic sensors. The lower sensor detects all objects on the floor within a 3-meter range, while the upper sensor detects objects within a 1.5-meter range between chest and head height. The two buttons vibrate in order to notify the patient of the distance and direction of the object or obstacle.

Figure 2. UltraCane

2.0 How It Works

The functionality of the Walking Wise increases user mobility through the detection of obstacles and relay of this information in a simplified manner. For example, in Fig. 3, the probing cane will detect the crosswalk and crosswalk sign and then alert the user through voice commands and vibration feedback when it is safe to cross, through detection of the walk sign signal. Upon the approach of any obstacle in the user's path, the vibration will notify the user. As the user gets closer to the obstacle, the vibration will increase in frequency.

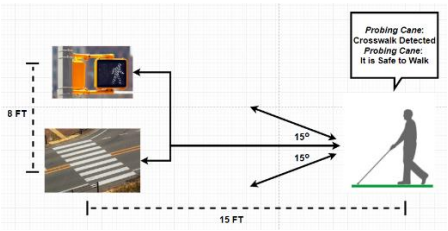

Figure 3. Crosswalk Diagram

2.1 Market Requirements

There are five major marketing requirements that must be fulfilled to satisfy project completion; safety, portability, longevity, user-friendliness and economy. Safety–Walking Wise must accurately detect staircases, overhanging obstacles and crosswalk signals. Walking Wise, built upon current aids and new technology, will replace the older model mobility aids. Portability–Walking Wise must be easily transported, with product weight as low as possible. Longevity–Walking Wise must be constructed to last a lifetime, with a minimum operating time of three hours before a recharge is required. User-friendly-Walking Wise must be able to operate Walking Wise with minimal training required. Economy–Walking Wise should be offered at a relatively low price to cater to individuals with low income or government assistance.

2.2 Control System

The probing cane is expected to assist the user in detecting the environment. To create a functional detection probing cane, the control system will be explored and analyzed. The required control system for the Walking Wise will be a closed loop system/feedback control system. The control system connects the electrical and mechanical components to software to control the functionality of the probing cane. The input of the system is the environment and obstacles in the surrounding area. The controller is a Raspberry Pi 3 B+ and the process is vibration and sound mechanism. The feedback loop includes a camera and ultrasonic sensor. The input will follow a forward path to the controller and process, which will loop into the feedback sensor system. Fig. 4 below provides a visual representation of the control system for our device.

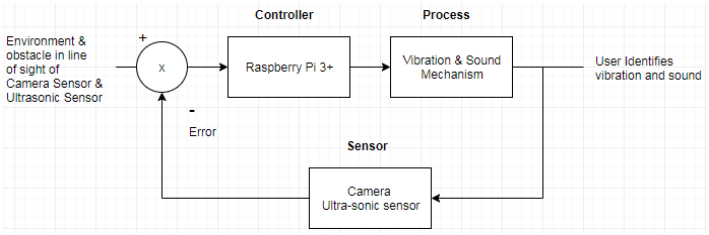

Figure 4. Control System

3. Stress and Safety Analysis

The probing cane is expected to undergo numerous points of loading during use. To create a strong and durable design, the mechanical system will be explored and analyzed. The mechanical system is based on bending moment. Figure 5 and 6 shows loading that the probing cane will undergo during use along with the formulae on how to evaluate stress and cane's safety as a result of bending load, Equation 1 and 2, respectively.

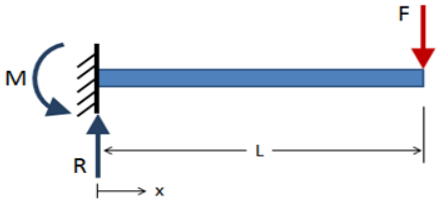

Figure 5. Mechanical System

Equation for the bending stress of the Cane is as follow:

$$\sigma = \frac{MC}{I} \qquad (1)$$

With σ = Stress, C= $\frac{Do}{2}$, M = Bending moment, Do = Outside diameter of the cane, and I = Second moment of Inertia

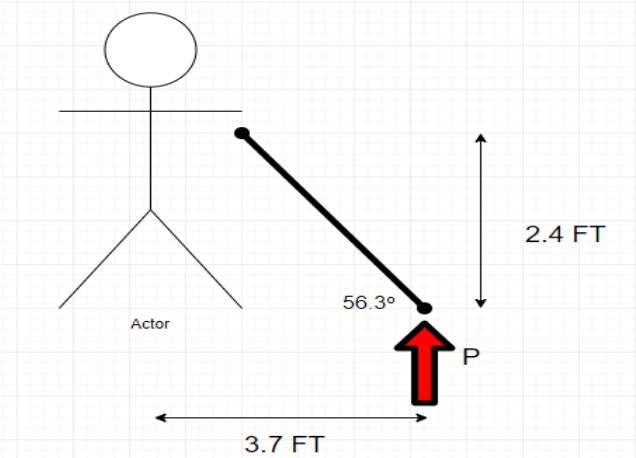

Figure 6. Bending Moment

Using (1) and (2), calculations are made to better understand the amount of loading required for the probing cane to regain its structural integrity during use. The amount of loading applied to the probing cane should result in elastic deformation. In the elastic deformation region, the probing cane will be able to bend without destroying the true structural strength of the material.

3.1 Factor of Safety (SF)

The factor of safety is defined as the ratio between the ultimate strength of the material and the maximum stress asserted on the probing cane. The maximum stress asserted on the probing cane is the loading that the cane will undergo.

$$FS = \frac{\sigma_{Ultimate}}{\sigma_{Applied}} \quad (2)$$

Moment calculations:
$M = F * d = 5\ lbs \cos(56.3)\ * 52\ in = 252\ psi$

Calculations of perpendicular distance from neutral axis:
$C = 0.75\ in$

Calculations of second moment of inertia:
$I = \frac{\pi}{64}(1.5^4 - 1.2^4) = 0.146\ in^4$

Calculations of applied stress:
$\sigma = \frac{MC}{I} = \frac{252\ psi * 0.75\ in}{0.146\ in^4} = 1295\ psi$

Calculations of Factor of Safety:
$$FS = \frac{2{,}000\ psi}{1{,}295\ psi} = 1.55\ (For\ PLA\ Material)$$
$$FS = \frac{42{,}000\ psi}{1295\ psi} = 32.44\ (For\ Aluminum\ Material)$$

For project purposes, the probing cane will be made of PLA material. However, PLA has a very low Ultimate Stress, the data yielded a low factor of safety of 1.55. For real world application the probing cane will be made of Aluminum to support a higher factor of safety of 32.44.

4. Engineering Requirements

Cane Dimensions: Total length: 1200 mm – 1500 mm, folded length: 250 mm – 360 mm, weight: 1300g. The probing cane will be 3D printed as a prototype. CATIA (Computer Aided Three-Dimensional Interactive Application) software is used to create the first prototype design of the probing cane. Fig. 7 represents the 3D Model design for the Smart Cane: Walking Wise. The prototype is composed from three main components; handle, housing case, and probing shaft.

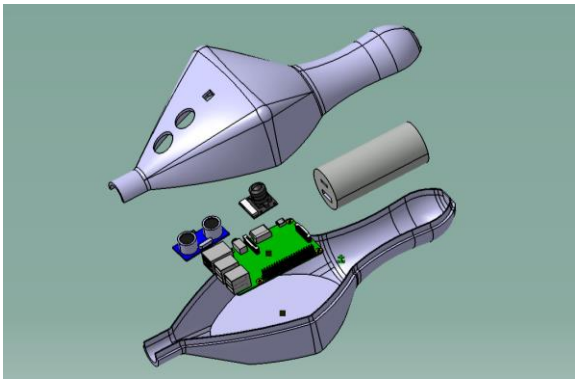

Figure 7. Prototype 1

4.1 Handle Design: Prototype 1

The cylindrical and ergonomic shape of the handle makes the grasp of the cane easy and comfortable. The handle is connected to a hollowed shell. The hollowed shell will serve as a location to house the components such as a battery source, thus reducing weight and material used. The battery source is stored in the shell and connected to the Raspberry Pi microcontroller via an extended micro-USB connection. The handle is the primary location of the vibrating feedback mechanism. The handle will vibrate when the ultrasonic sensor senses an object or obstacle at a distance. The vibrating motors will be stored inside the handle and this placement will optimize the vibrating feedback system, so the user will easily feel the vibration. Since the probing cane is a uniform design, the vibration will travel throughout the whole design. To reduce the amount of vibration shared onto the other components of the design, an anti-vibration material will be used on that site. The anti-vibration material will be used as a shock-absorbent to prevent the electrical components from moving and prevent the wiring from disconnecting. The anti-vibration material as shown in Fig. 8 is designed in such a way to locate the vibration on the handle and insulate the components located in the housing case.

Figure 8. Anti-vibration material

4.2 Housing Design: Prototype 1

The housing case stores all the electrical components such as the Raspberry Pi microcontroller, Raspberry Camera, Ultrasonic sensor, and Mini Metal Speaker. The design and placement of the components are made to use as minimal a surface area as possible. Utilizing minimal surface area will reduce the size and weight of the probing cane and will provide better performance and functionality. This design is also cost effective, because it minimizes the amount of 3D material needed to print the design. Fig. 9 shows the electrical components stored in the housing case.

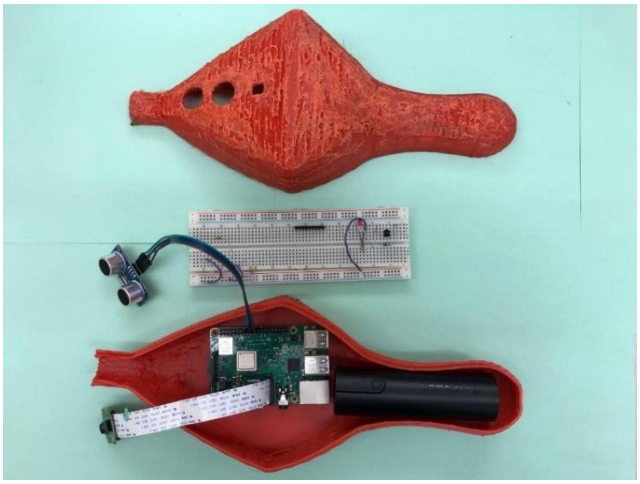

Figure 9. Housing Case with components

4.3 Probing Shaft Design: Prototype 1

The probing shaft will be designed to withstand the stress of probing the ground. A finite element analysis is conducted to provide data of the structural integrity of the probing cane under loading. The loading that the probing cane is expected to undergo will be buckling stress and bending stress. Buckling loading is explored using Euler's equation, while bending loading is explored using the bending equation. Calculations are made using the best-suited material for the probing cane. The material is selected on the basis of price and structural strength.

4.4 FEA Analysis: Prototype 1

Using CATIA software, a FEA (Finite Element Analysis) was conducted on the first prototype. The finite element analysis yielded data that suggesting the need to re-design the project, since the structural integrity is questionable.. There were many location points where the design failed under minimal loading shown in Fig. 10. As for project purposes, prototype 1 will be used to complete the project. In Fig. 10, a load of 100N was loaded on the perpendicular to the handle. This load represents a bending deformation that the handle will undergo during daily use.

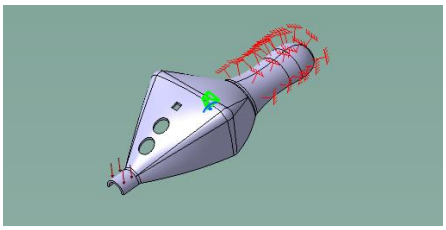

Figure 10. Loading on Prototype 1

Fig. 11 shows the 3D model major failure location points. The probing cane fails at areas colored in green, yellow and red. Most of the critical failure points are located on the handle connection of the housing casing. This component will experience failure if these issues are not addressed. It is safe to assume that failure occurs due to the drastic change of cross-sectional area which is a key concept in solving the problem. The problem can be fixed by gradually increasing the cross-sectional area to prevent structural failure. In the future redesign, the handle should gradually connect to the housing case in a cone shape design. This will also reduce the number of sharp edges that can lead to failure. By having a cone shape design throughout the handle to the probing shaft, the failure locations can be dismissed, thus creating a stronger, more durable probing cane.

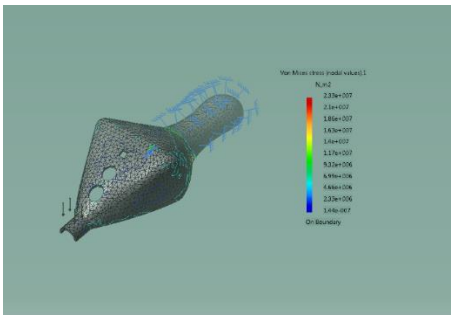

Figure 11. Failure on Prototype 1

4.5 Electronics Packaging: Prototype 1

Fig. 12 represents the layout of the electrical components that are stored in the housing case of the design. The list of the components are shown in Table 1.

Table 1.

Component's Name	Quantity
Raspberry Pi 3 Model B+	1
Ultrasonic Sensor HC-SR04	1
Vibrating Motors	1
Piezo Speaker	1
Breadboard	2
1000 Ω Resistor	3
470 Ω Resistor	2
Diode Rectifier 1A 50V	2
Transistor NPN B0337	2
Connection Wires	25

In the design, the breadboard is located directly on top of the Raspberry Pi to reduce area consumption of the housing case. The power source is connected via micro USB to a battery source located in the handle shell. The sensor components are in specified areas of the housing case to improve detection of obstacles and view path. The components are mounted and cased in a thin layer of anti-vibration material (Fig. 7). The anti-vibration material's purpose is to negate the minor vibration caused by the vibrating motors. Reduction in the vibration of the main components may prevent damage and disconnection of wires while the probing cane is in use. The schematic shown in Fig. 12 describes the layout of all the components connected by a breadboard to prove functionality of the probing cane. The components are elevated using pillars in the design to prevent rubbing or touching of the 3D printed design also keeping the components stable in the housing case. The Raspberry Pi Camera is connected to the camera port on the Raspberry Pi microcontroller. The Ultrasonic sensor is connected in series with a 1000 Ohm and a 470 Ohm Resistors via breadboard and pin ports on the Raspberry Pi microcontroller. The speaker is connected in series with a Transistor - NPN B0337 via breadboard and pin ports on Raspberry Pi microcontroller. The vibrating motors are connected in series with a Diode Rectifier via breadboard and pin ports on the Raspberry Pi microcontroller.

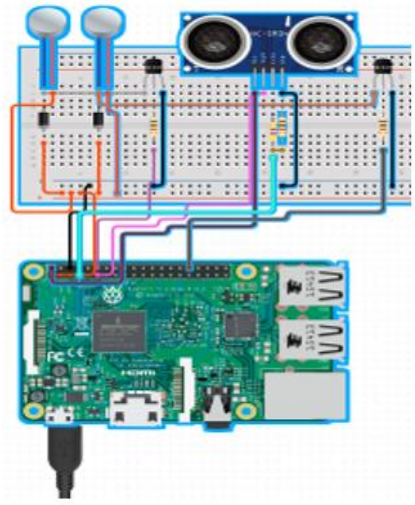

Figure 12. Electrical Schematic

5. Image Recognition

The rapid rise of technology has resulted in significant computer Artificial Intelligence (AI) developments which have led to the establishment of Computer Vision (CV). Computer Vision is a field of computer science that allows computers to detect, identify and process their environment in a way similar to humans [4]. As development of CV expanded, it has been applied to the field of image recognition/object detection, the process of identifying real-world objects in images or video feeds. Object detection has already found its way into consumers' lives in the form of surveillance systems, facial recognition and advanced driver assistance systems (ADAS) [5]. Walking Wise expands the use of CV to a more humanitarian field by utilizing object detection to grant visually impaired individuals a better understanding of their surroundings.

5.1 TensorFlow

TensorFlow is an open source machine learning framework specialized for numerical computation [6]. The flexible nature of TensorFlow allows it to deploy on CPUs and GPUs in devices ranging from desktops to mobile devices. TensorFlow features stable Python application programming interface. Subsequently, TensorFlow is ideal for this application, since it allows engineers to train on a home desktop and then run it on the mobile Raspberry Pi 3B+, code in Python, and manage the high data processing of image recognition. Once TensorFlow is downloaded and formatted, the required packages are downloaded, and paths are established. The anaconda virtual environment is then set up providing a workspace to configure, test, and troubleshoot TensorFlow.

5.2 Implementation

Walking Wise will combine a Raspberry Pi microcomputer, a high-quality camera and a trained object detection model to create an intelligent system capable of detecting and categorizing objects/obstacles in its environment. For the purpose of this project, the focus is on following three essential tasks; detecting when a user has encountered a crosswalk, determining the status of the pedestrian signal, and relaying this information to the user through a mixed feedback system consisting of vibration and sound. The model will be trained using the ssd_mobilenet TensorFlow model provided by Google as the base of a custom trained object detection model [7]. There are four main steps that make up the training process: compiling TensorFlow and the required packages, gathering and labeling sample images as raw data, conducting training on a host PC and finally testing and troubleshooting the model. Fig. 13 highlights a key section of the object detection script. The key processes within that snippet are the classes and scores functions which are responsible for classifying each object detected and producing its confidence factor respectively. Using these classifications and their confidence factors, we can then implement a unique feedback system for each class detected of a certain confidence factor. Fig. 13 shows a working prototype of our object detection model being used to detect our objects of interest. As shown in the figure, we are comfortably detecting our objects of interest and are achieving high confidence factors.

```
        # Perform the actual detection by running the model with the image as input
        (boxes, scores, classes, num) = sess.run(
            [detection_boxes, detection_scores, detection_classes, num_detections],
            feed_dict={image_tensor: frame_expanded})
        # Draw the results of the detection (aka 'visulaize the results')
        vis_util.visualize_boxes_and_labels_on_image_array(
            frame,
            np.squeeze(boxes),
            np.squeeze(classes).astype(np.int32),
            np.squeeze(scores),
            category_index,
            use_normalized_coordinates=True,
            line_thickness=8,
            min_score_thresh=0.40)
```

Figure 13. Image Recognition Code

Walking Wise will require no user input as detection and feedback are handled by the device itself. Walking Wise will implement a technique called Edge Computing where all computing, raw data collection, analysis of data, and feedback, are completed on site eliminating the need for cloud servers [8]. This will significantly reduce latency and allow for real-time processing and feedback of data. Through the combination of our Raspberry Pi 3b+, a Raspberry Pi Camera, and a well-trained object detection model, Walking Wise will gift the visually impaired community greater independence.

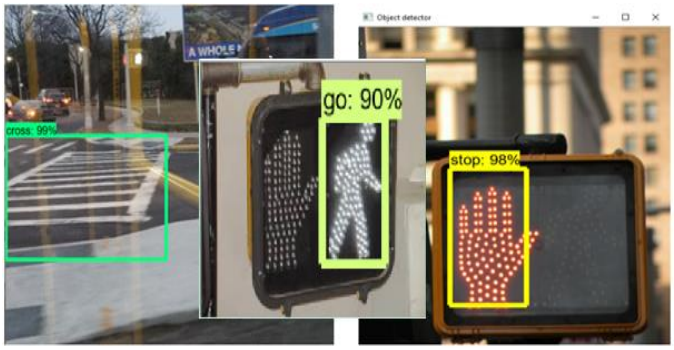

Figure 14. Imagine Recognition (Sign)

5.3 Working Principle

The basic working principle of this device is as follows: Raw data is collected by the device in the form of a live video feed from the camera. The object detection model continuously scans and analyzes the data, searching for objects it is trained to detect. When a detection of a high confidence factor is reached (the model outputs a confidence factor which is a percentage of how accurate the model thinks its detection is), this information will then be sent to the feedback system. The user will then receive feedback from the device in the form of sound and vibration, informing the user to the nature of the obstacle and what actions may be taken.

5.4 Movidius Neural Compute Stick

The performance of the imaging system is boosted through the addition of Intel's Movidius Neural Compute Stick (NCS) [9]. The NCS is a small deep learning device that allows AI programming to be done on the edge. It is powered by Intel's Movidius Vision Processing Unit (VPU) that allows

developers to profile, tune, and deploy convolutional neural networks (CNN) and deep neural networks (DNN) for low-power applications that require real-time inference. This VPU will significantly improve the frame rate (fps) of the device, reducing latency and bring Walking Wise close to real-time detection. The working principle of the device can be seen in Fig. 15.

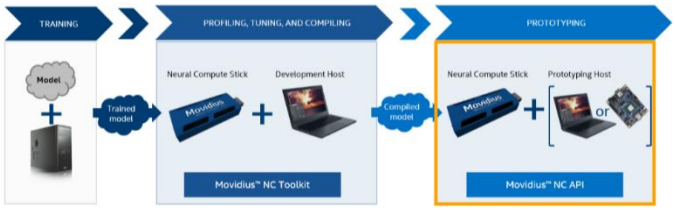

Figure 15. Movidius Neural Compute Stick

Ultrasonic Sensor Working Principles

An Ultrasonic Sensor is a device that can measure the distance between the sensor and an object using sound waves. Sound waves are emitted from the sensor outwards and the sensor then listens for the returning sound waves. If an object is within the range of the sensor, the sound waves bounce of the object back to the sensor. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back and knowing the speed of sound it is possible to calculate the distance between the sonar sensor and the object [10]. This concept is implemented in the python code shown in Fig. 16.

```
def distance():
    # set Trigger to HIGH
    GPIO.output(GPIO_TRIGGER, True)
    # set Trigger after 0.01ms to LOW
    time.sleep(0.00001)
    GPIO.output(GPIO_TRIGGER, False)

    StartTime = time.time()
    StopTime = time.time()

    # save StartTime
    while GPIO.input(GPIO_ECHO) == 0:
        StartTime = time.time()

    # save time of arrival
    while GPIO.input(GPIO_ECHO) == 1:
        StopTime = time.time()

    # time difference between start and arrival
    TimeElapsed = StopTime - StartTime
    # multiply with the sonic speed (34300 cm/s)
    # and divide by 2, because there and back
    distance = (TimeElapsed * 34300) / 2

    return distance
```

Figure 16. Ultrasonic Code I

5.5 Implementation

Traditional probing canes can only detect obstacles in the user's immediate path with a ground touch point. Hanging objects that lack a ground touch point cannot be detected with a traditional probing cane, leading to injury. To combat this issue, an ultrasonic sensor is incorporated into the Walking Wise to detect hanging objects. The HC-SR04 ultrasonic sensor is the choice of sensors and will cover the area from the user's hip to the user's head. The sensor will be strategically mounted onto the outside surface of the cane so that it provides optimal detection and minimal obstruction. When an object is detected by the sensor, a vibration feedback is produced. A three-

phase feedback system, whose implementation can be seen in Fig. 17, will be implemented for different levels of detection. Objects within the 100-150 cm range will trigger Phase 1, a low vibration feedback. Objects within the 50-100 cm range will trigger Phase 2, a medium vibration feedback. Objects within 50 cm will trigger Phase 3, a high vibration feedback.

```
pi@raspberrypi:~/Desktop/WorkingCodes $ python3 UltrasonicOutput.py
Measured Distance = 41.0 cm
Vibration level 3
Measured Distance = 41.8 cm
Vibration level 3
Measured Distance = 41.3 cm
Vibration level 3
Measured Distance = 59.2 cm
Vibration level 2
Measured Distance = 60.7 cm
Vibration level 2
Measured Distance = 59.5 cm
Vibration level 2
Measured Distance = 81.1 cm
Vibration level 2
Measured Distance = 84.7 cm
Vibration level 2
Measured Distance = 92.5 cm
Vibration level 2
Measured Distance = 95.1 cm
Vibration level 2
Measured Distance = 101.5 cm
Vibration level 1
Measured Distance = 101.0 cm
Vibration level 1
```

Figure 17. Ultrasonic Code II

6.0 Components

Raspberry Pi 3 – Model B+ [11]:
Product dimensions: 87.0 mm x 58.5 mm x 18.0 mm, product weight: 49.7 g, processor: Cortex-A53 64-bit SoC @ 1.4GHz. Memory: 1GB SDRAM, connectivity: USB 2.0 ports, access: 40-pin GPIO header, video: MIPI CSI camera port, input power: 5V/2.5A DC via micro USB connector, output power: 5V/3.3V DC via GPIO header.

Figure 18. Raspberry Pi

The functionality of the Raspberry Pi is to serve as the brain for this device and perform all computations.

Raspberry Pi Camera [12]:
Product Dimensions: 17 mm x 2.5 mm x 2 mm, product weight: 5g. High definition 5MP camera module. Field of view: 65 degrees

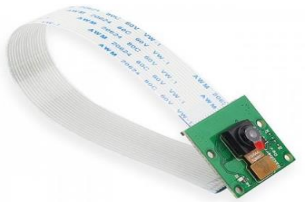

Figure 19. Raspberry Pi Camera

The Raspberry Pi Camera will serve as the input sensor for object detection.

HC-SR04 Ultrasonic Sonar Distance Sensor [13]:
Input Voltage: DC 5V, power consumption: 15mA, ultrasonic frequency: 40 KHz, measuring angle: 15º, trigger input signal: 10uS high pulse, sensor dimensions (excluding header): 45.5 x 20 x 15.5mm, weight: 8.7g.

Figure 20. Ultrasonic Sensor

The functionality of the Ultrasonic sensor is to detect distances of objects and relay data to the Raspberry Pi.

Vibrating Mini Motor Disc [14]:
Dimensions: 10 mm diameter, 2.7 mm thick, voltage: 2V - 5V, current draw: 40mA - 100mA, RPM: 11000 at 5V, weight: 0.9 gram.

Figure 21. Vibrating Motors

The functionality of the vibrating motors is to provide vibration feedback to the user.
Stereo Enclosed Speakers [15]:
Dimensions: 30 mm x 70 mm x 17 mm, weight: 50g, power: 3W, impedance: 4ohm.

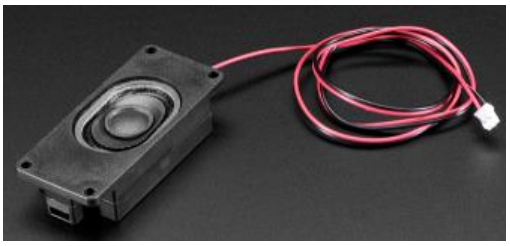

Figure 22. Speaker

The functionality of the speaker is to provide audio feedback to the user.

Power Supply [16]:
Dimensions: 33 mm x 107 mm, capacity: 5000mAh, output: 5V/2.4A, weight: 181g.

Figure 23. Battery

The functionality of the battery is to power the Raspberry Pi.

7. Conclusion

The Wise Cane's goal is to incorporate technological solution into the traditional cane while maintaining an affordable price. The cane's design was altered to give the patient a more comfortable and ergonomic handle. Test and observations have proven that the Wise Cane will attend its objective by satisfying certain needs of the visually impaired users. Using the camera detection, the ultrasonic sensor and Arduino board along with the vibration motor, the smart cane greatly improved the object detection range and increased the patient's independency in moving around. Overall, the Wise Cane will greatly enhance the life-style of the visually-disabled, as well increase their involvement in society.

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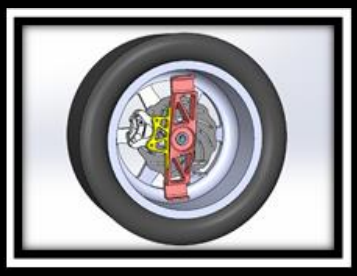

“Tell me and I forget. Teach me and I remember. Involve me and I learn.”

Benjamin Franklin