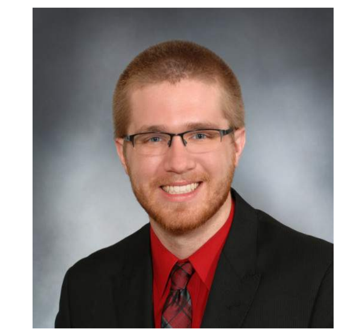
Robotic Flight Simulator

Problem

- Current flight simulators are costly to build and not interchangeable between different flight models.
- The relationship between human and robots requires improvement.





Austin Kucinski, Heath Palmer, & Nathan Huber

All members are pursuing a Bachelors degree in Electrical Engineering Technology

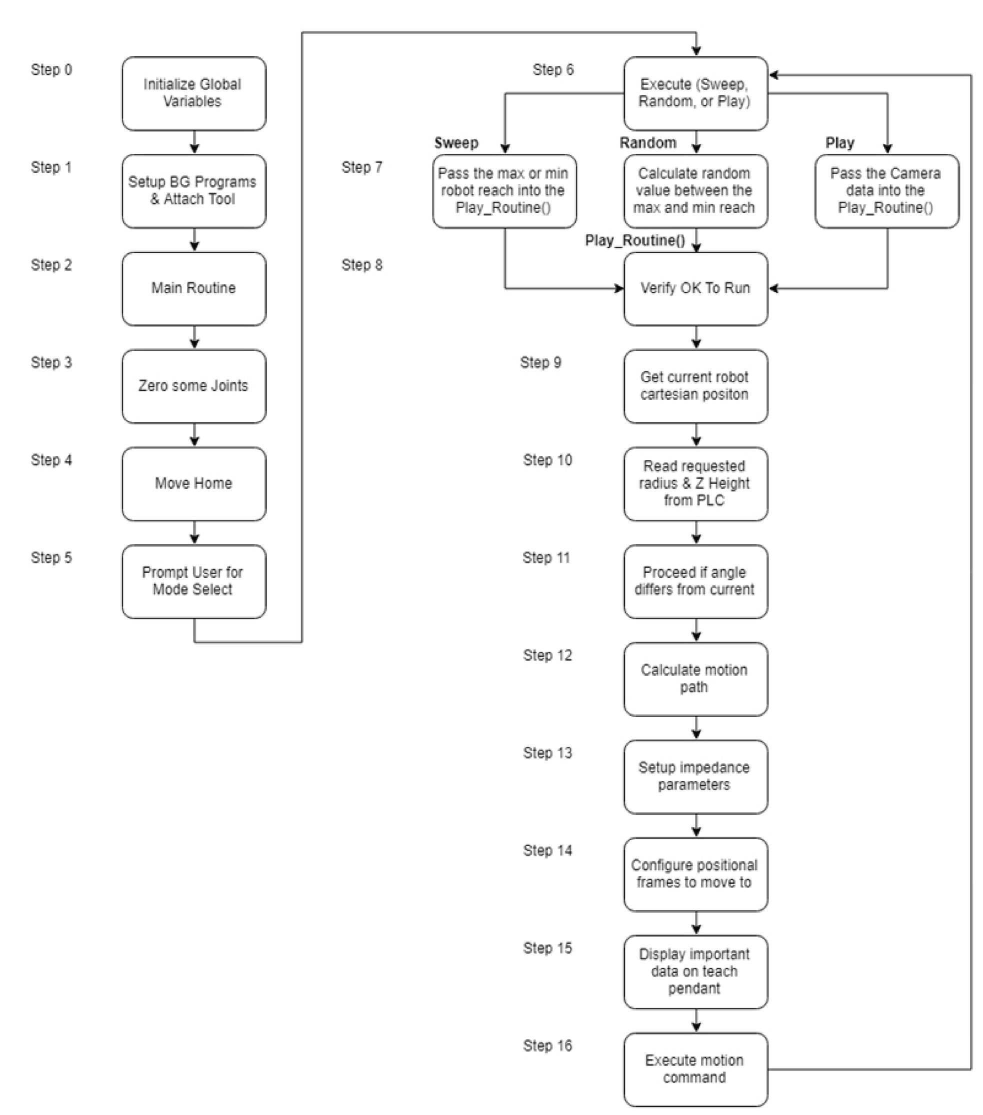
Conclusion

- The Robotic Flight Simulator will provide a cheaper method of simulating airplane controls and improve the human - robotics relationship. The project has a very tight deadline, but the team is capable of handling the task.

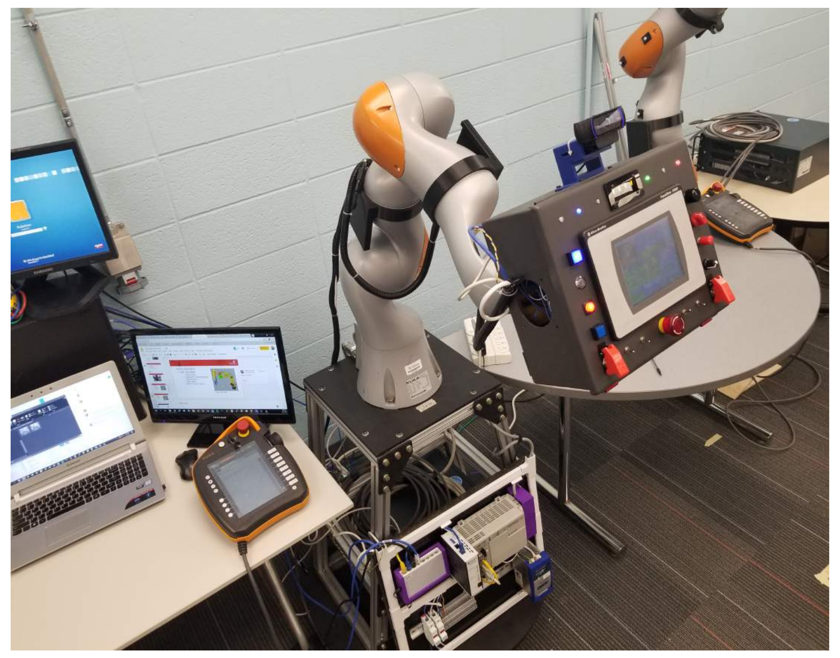
Goals

- Design the first step of a human-robot environment with the intent to train users hot to fly planes.
- Ensure high levels of safety and system quality.
- Align system design and goals with Dr. Ma.
- Assemble robotic system for use with the end of arm tooling (EOAT) and computer vision system.
- Prepare for use with Kuka and Fanuc collaborative robots.
- Submit an abstract to The 70th International Astronautical Congress in Washington, DC.
- The system will allow the user to interact kinesthetically with the system while providing a similar workspace area to a full-scale flight simulator.

Robotic Theory

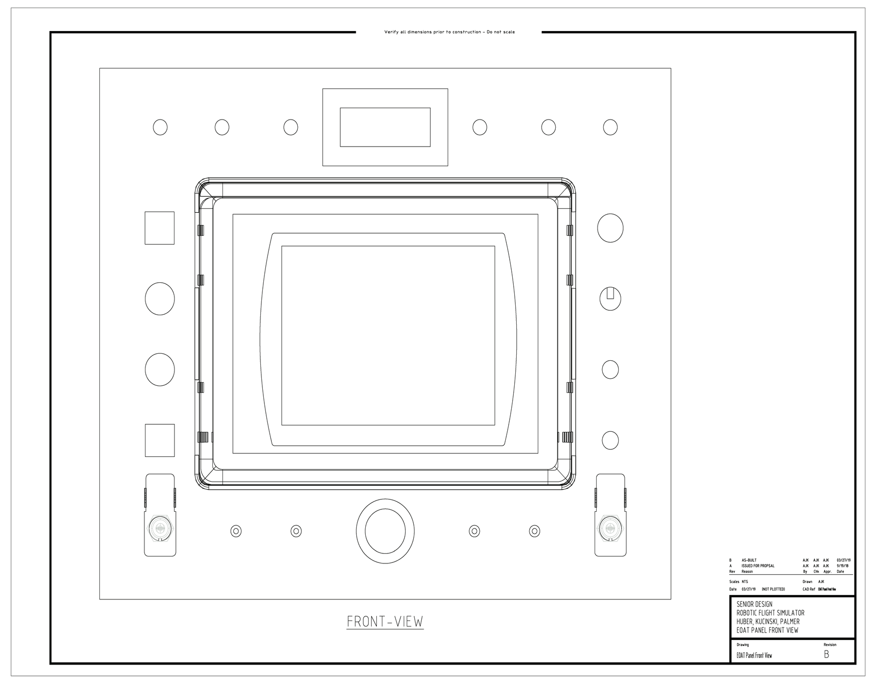


Results



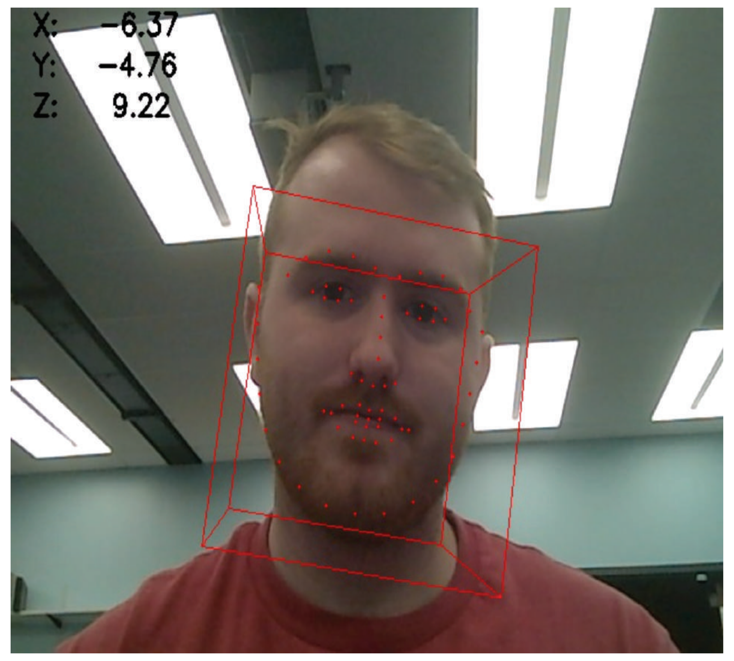
Robotics

The data collected is the user's cartesian coordinates (X, Y, Z, W, P, & R) within the camera's field of view. The Roll (R) data will be parsed and converted into a 16-bit integer value and transmitted to the PLC over Ethernet/IP. The robot determines the threshold of when to move to the new coordinate values. The robot takes the new head angle provided by the PLC and computes its path to follow within an arc fashion.



End of Arm Tooling (EOAT)

The control panel has a variety of switches and indicators for the user to interact with. These do not have any effect on the robot's operation but are only for aesthetic purposes. The operation of the switches and indicators is controlled by an Arduino Nano. The Arduino Nano does not have sufficient I/O pins for the number of devices designed for. Therefore, an I2C bus driver is utilized to expand the number of I/O pins.



Tracking - Head Pose Estimation

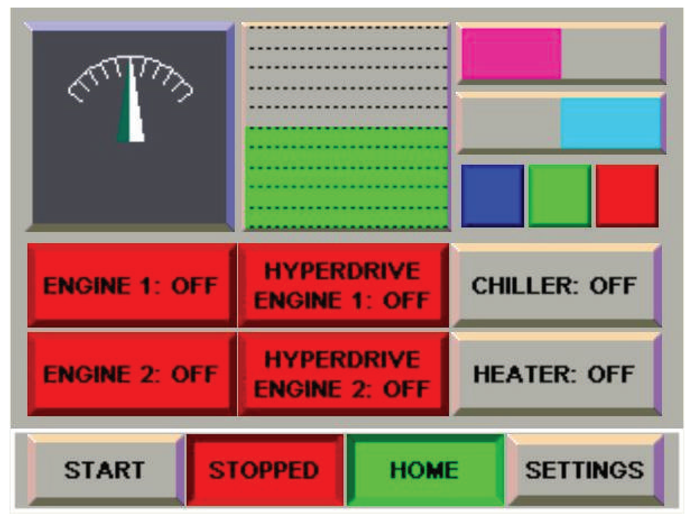
The user's head angle and the location is collected by a Logitech HD C920 Camera. A desktop computer runs the python program that estimated the user's head Euler angles. These angles are estimated using position data of the user's face with 68 point tracking around the eyes, nose, mouth, and head. The OpenCV library is used for the computer vision. These Euler angle values are sent to the Kuka robot and utilized for the robot's motion accordingly. A filter is applied to the python program to reduce the "gitter" or error while estimating the Euler angles. The library used is: head-pose-estimation by lincolnhard.

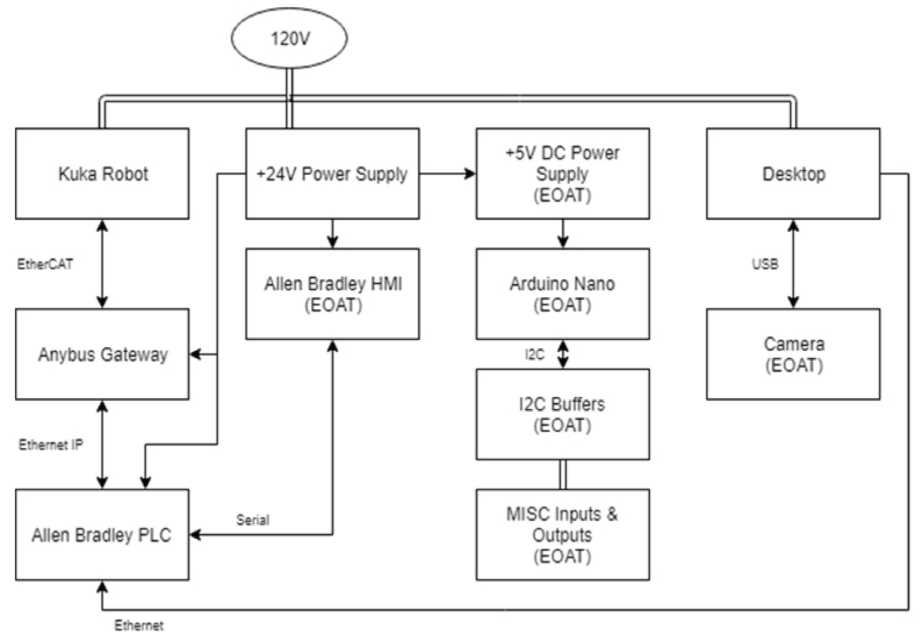
Future Plans

Next steps include:

- Run user tests to achieve high accuracy with the current setup.
- Develop the Virtual Reality (VR) Component.
- Integrate VR and Robotic into one engaging interactive flight simulator.
- Further develop the project and run new user tests and compare results from other flight simulators.

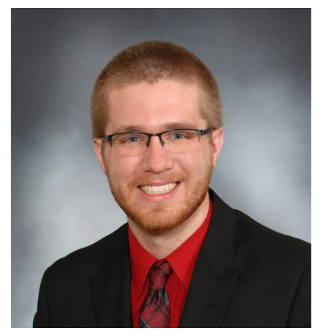
EOAT & Tracking





Robotic Flight Simulator





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General Project Management

- Safety
- Facilities
- Schedule
- Bill of Materials (B.O.M.)
- Simulator Topics
- Credibility
- Advisors + Acknowledgement

Safety

- High visibility duct tape showing the robots' maximum reach.
- Sign(s) warning of robot motion.
- Configuring limits internal to the robot.
- Foam attachments around the End Effector (Control Panel) to reduce hard edges.
- The Blue LED Ring Light will illuminate prior to the motion.
- Nathan will hold the Teach pendant for a E-Stop.
- There is a red button on the robot's control panel that will pause the robot. This is non-safety rated.

Facilities

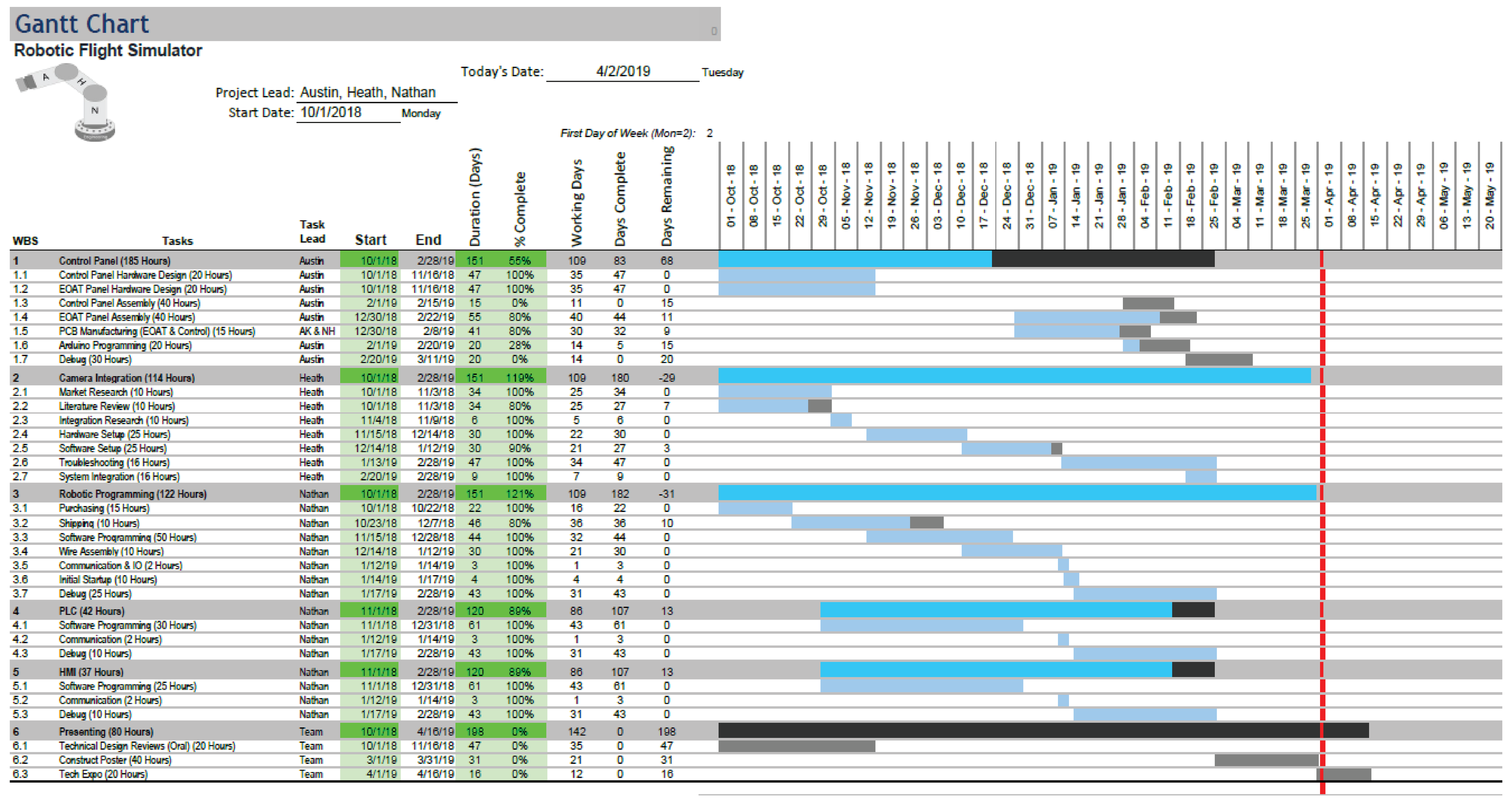
Our project has utilized the following facilities:

- Dr. Ou Ma's lab: The Kuka and Fanuc robots are stationed here alongside most of the capstone integration. This includes robotic arm programming & testing, computer vision integration testing, and EOAT integration testing.

- IRAS Lab (Dr. Ma)
  - Kuka Robot
  - Fanuc Robot
  - Testing facilities

- EECS
  - Desktop
  - PLC
  - HMI

Schedule



With a capstone project of this size, the timeline is rushed. It is anticipated to have all hardware and software completed promptly after Christmas break. Integration and debug will start at the beginning of January. The estimated timeline. The Gantt chart does not follow the typical downward stair-step pattern because each team member will play a key role within the development of the project while working independently.

Bill of Materials (B.O.M)

Senior Design: Robotic Flight Simulator (1/3)
Bill of Material

Members: Nathan H, Austin K, & Heath P

University Funded
Personally Funded

Line Item:	Qty:	Catalog Number:	Description:	Manufacturer:	Vendor:	Supplier:	Unit Cost:	Total Cost:
1000	1	CR35-iA	Fanuc Robot	Fanuc	Fanuc America	University of Cincinnati	$45,710.00	$45,710.00
1001	1	Software Options	Robot Software Additions	Fanuc	Fanuc America	University of Cincinnati	$9,828.90	$9,828.90
1002	1	R820-14	Kuka iwa	Kuka	Kuka	University of Cincinnati	$50,000.00	$50,000.00
1003	1	C600	AB HMI 6"	Allen Bradely	Rockwell	University of Cincinnati	$500.00	$500.00
1004	1	1769-L23E-QB1B	CompactLogix PLC	Allen Bradely	Rockwell	University of Cincinnati	$1,200.00	$1,200.00
1005							$0.00	$0.00
1006	1	Logitech - C920 Web Cam	C920 Web Cam	Logitech	Logitech	Heath Palmer	$50.00	$50.00
1007							$0.00	$0.00
1008	2	A-1640	Rotary Switch 4 Pole 3 Position	Tayda Electronics	Tayda	Austin Kucinski	$0.89	$1.78
1009	3	A-5098	Black Plastic Knob with Green Pointer	Tayda Electronics	Tayda	Austin Kucinski	$0.22	$0.66
1010	5	A-322	Black Plastic Knob with White Pointer	Tayda Electronics	Tayda	Austin Kucinski	$0.22	$1.10
1011	3	A-1962	1K OHM Linear Taper Potentiometer	Tayda Electronics	Tayda	Austin Kucinski	$0.50	$1.50
1012	5	A-706	LED 5mm Red	Tayda Electronics	Tayda	Austin Kucinski	$0.02	$0.10
1013	5	A-057	LED 5mm Green	Tayda Electronics	Tayda	Austin Kucinski	$0.03	$0.15
1014	5	A-407	LED 5mm Blue	Tayda Electronics	Tayda	Austin Kucinski	$0.05	$0.25
1015	5	A-1583	LED 5mm Yellow	Tayda Electronics	Tayda	Austin Kucinski	$0.03	$0.15
1016	5	A-4567	Mini Toggle Switch SPDT On-On	Tayda Electronics	Tayda	Austin Kucinski	$0.47	$2.35
1017	3	A-179	LM7805 Voltage Regulator	Tayda Electronics	Tayda	Austin Kucinski	$0.23	$0.69
1018	50	A-2115	10K OHM 1/4W 5% Resistor	Tayda Electronics	Tayda	Austin Kucinski	$0.01	$0.50
1019	5	A-001	8 pin DIP IC Socket Adaptor	Tayda Electronics	Tayda	Austin Kucinski	$0.03	$0.15
1020	5	A-1601	28 pin DIP IC Socket Adaptor	Tayda Electronics	Tayda	Austin Kucinski	$0.11	$0.55
1021	1	A-5162	Copper Clad Board PCB	Tayda Electronics	Tayda	Austin Kucinski	$1.89	$1.89
1022	20	A-2119	220 OHM 1/4W 5% Resistor	Tayda Electronics	Tayda	Austin Kucinski	$0.01	$0.20
1023	10	A-2067	330 OHM 1/4W 5% Resistor	Tayda Electronics	Tayda	Austin Kucinski	$0.01	$0.10
1024	16	A-2940	PCB support with Adhesive Back	Tayda Electronics	Tayda	Austin Kucinski	$0.10	$1.60
1025	1	A-2849	Knurled Aluminum Black Knob	Tayda Electronics	Tayda	Austin Kucinski	$1.29	$1.29
						University Funded:	$107,288.90	$107,288.90
						Personally Funded:	$288.87	$382.80
						Group:	$288.87	$382.80
						Total Cost:	$107,577.77	$107,671.70

The breakdown of the budget is shown above. Most of the supplies will be provided by Nathan and the remaining supplies will be purchased using the money allotted by the College of Engineering.

Simulator Topics

- The first part of the flight simulator focusses on hardware design, development, and integration for a preliminary representation of a more complex flight simulator. Aircraft control representativeness, aircraft model flexibility, and cost were primary concerns in this step.
- Next, a complete visual representation of the aircraft shall be implemented through Virtual Reality (VR). The external environment and faircraft flexibility topics shall be implemented in this step.

Credibility

The three students, Austin Kucinski, Heath Palmer, and Nathan Huber, are all pursuing a Bachelor of Science in Electrical Engineering Technology at the University of Cincinnati. Each student has experience with electrical design and programming within industrial and research environments. Individually, each student has greater strengths within a section of the electrical field.

Austin specializes in industrial hardware design and integration.

Heath specializes in vision and camera utilization.

Nathan specializes in industrial programming and robotics.

The experiences the group gained within the classroom and on Co-Op interlink with the proposed project. All of these skills, classroom and hands-on, will further strengthen the quality and durability of the project proposed.

Advisors + Acknowledgement

Dr. Ma
Dr. Rabiee
EH&S & UC Facilities