3-Way Syringe

Mixing Team

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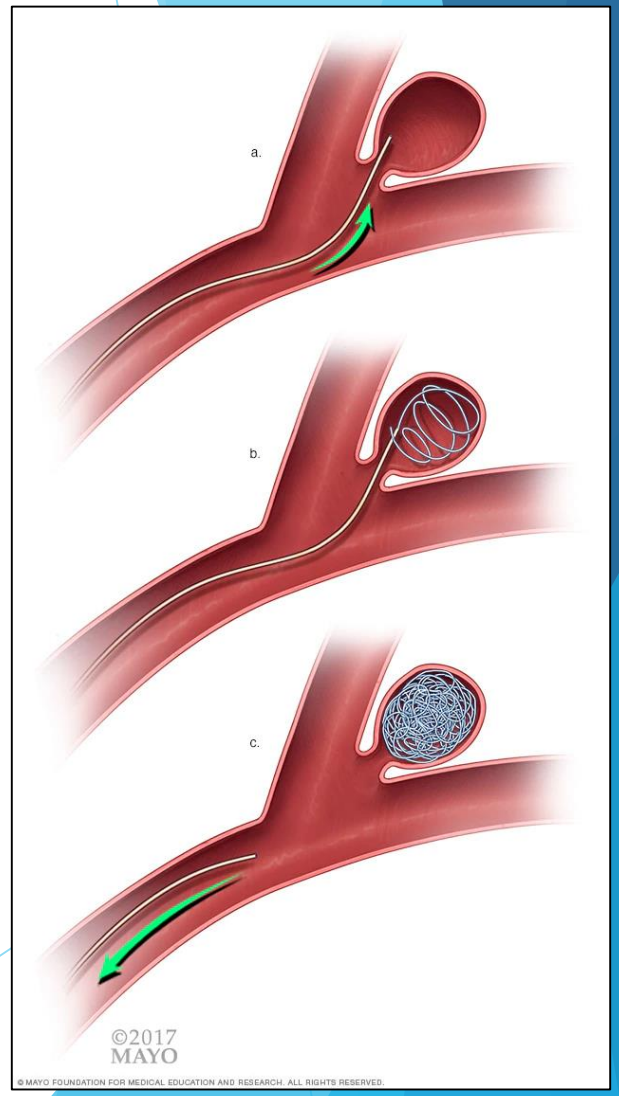
Background

Our Problem:

Aneuvas Technologies is developing a medication to treat Brain Aneurysms. Medication efficacy is directly correlated with the amount of energy imposed on the liquids during mixing, so the researchers cannot systematically produce samples by hand.

Our Goal:

Develop a clinical system to mix the three liquid medical components with reliable, user-defined, and continuously reproducible mixing results.



User Requirements

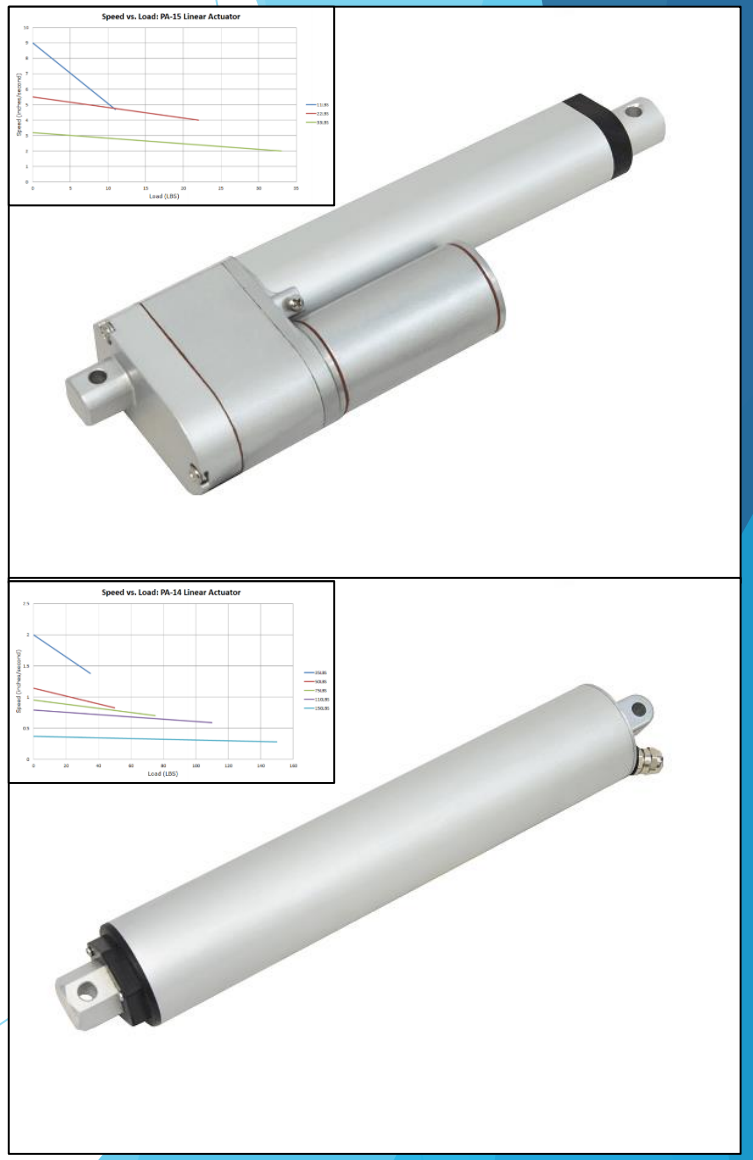
- Device must mix at a minimum speed of 2 inches/second.
- Device must be easy to use for persons with limited technical backgrounds.
- Device must be easily transportable by a single person.
- Device must produce as little dead liquid volume as possible.
  - Dead Volume – Volume of liquid remaining in syringe connector after mixing.
- Device must be easy to sanitize for safe use in medical facilities.

Initial Brainstorming

- Utilize Linear Actuators (Motors) for syringe mixing.
- Utilize Linear Potentiometers to control motor position and speed.
- Construct or purchase a Motor Driver capable of controlling three motors.
- Utilize a Microcontroller capable of controlling our system.
- Design a Graphic User Interface (GUI) for user ease and mix rate inputs.
- Construct a Mounting System to conserve as much space as possible and be easily transportable.

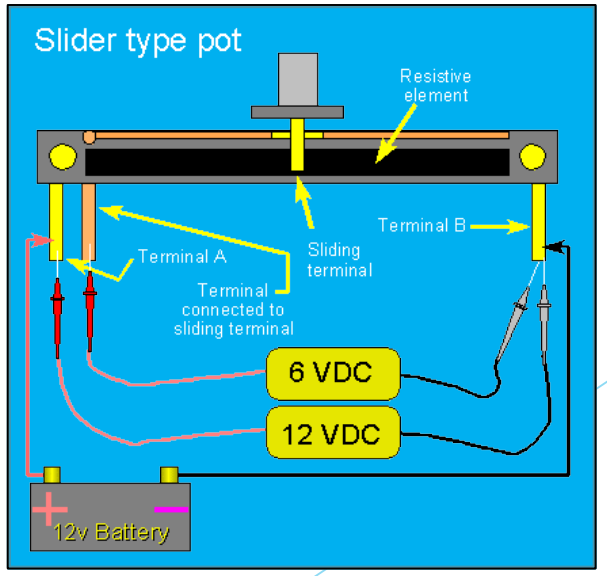
Linear Actuators

- Initial Choice:
  - PA-14P Feedback Linear Actuator model with built-in Linear Potentiometer.
    - Motors rated for max speed of 2.00 inches/ second.
  - Initial tests showed motor speeds were not reaching 2 inches/ second.
    - Learned that Motor Speeds have negative linear relationship to push weight.
    - Any amount of weight on the motors caused speeds to be below minimum requirement.
- Final Choice:
  - PA-15 High-Speed Linear Actuator model.
    - Motors rated for max speed of 9.05 inches/ second.
  - Double the size of the PA-14P model, but necessary for motor speed range required.



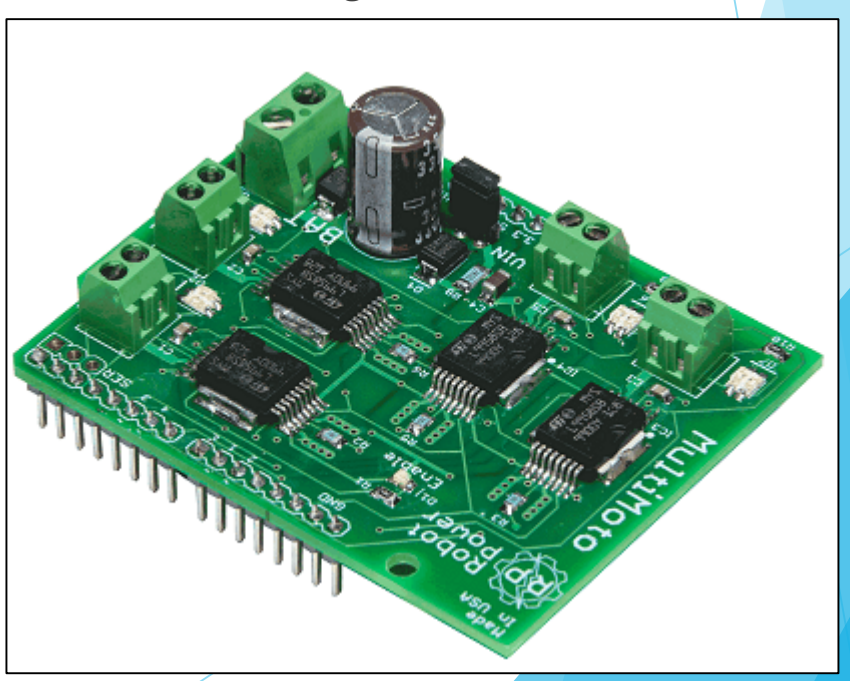
Linear Potentiometer

- Variable Resistor whose output voltage determined by the sliding terminal's position on top of a resistive element.
- Read this voltage value as a fraction of motor extension length.
- Initial Choice:
  - Use the PA-14P Feedback Linear actuator with built-in Linear Potentiometer.
  - Decided against for reasons previously described.
- Final Choice:
  - LPPS-22 Series Linear Potentiometer
  - Connected to Motors using hose-clamps and screws.



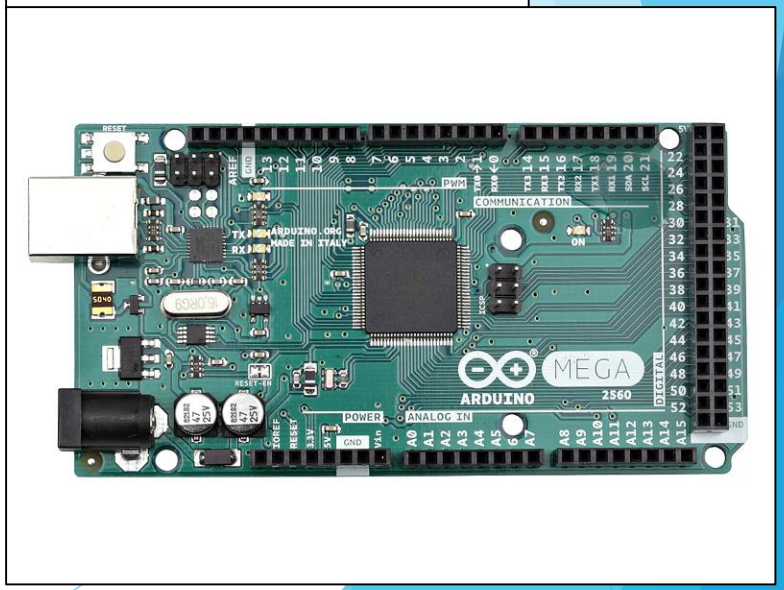
Motor Driver

- Initial Ideas:
  - Construct a motor driver using Relays and H-Brides.
  - Eventually realized that this is where the previous team went wrong.
  - Building a motor driver with current overload protection is difficult for novice engineers.
- Final Choice:
  - MultiMoto Arduino Shield
    - Compatible with PA-15 motors and Arduino microcontroller.
    - Built-in H-bridges and current overload protection circuits.
    - Built-in voltage regulator for motor speed control.
    - Supports up to four motors to run simultaneously.



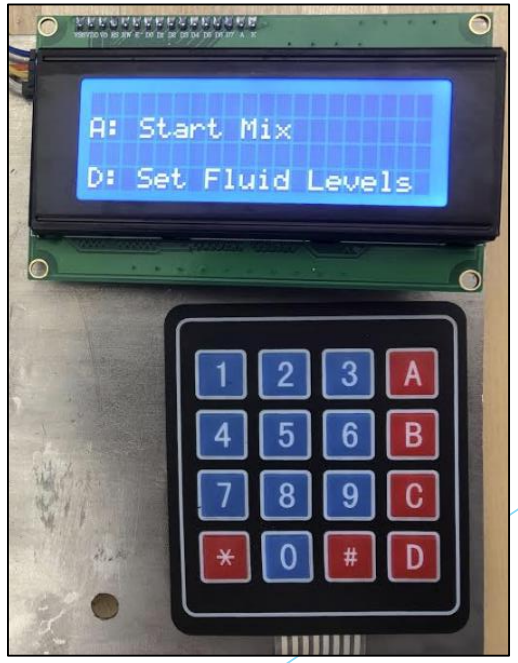
Microcontroller

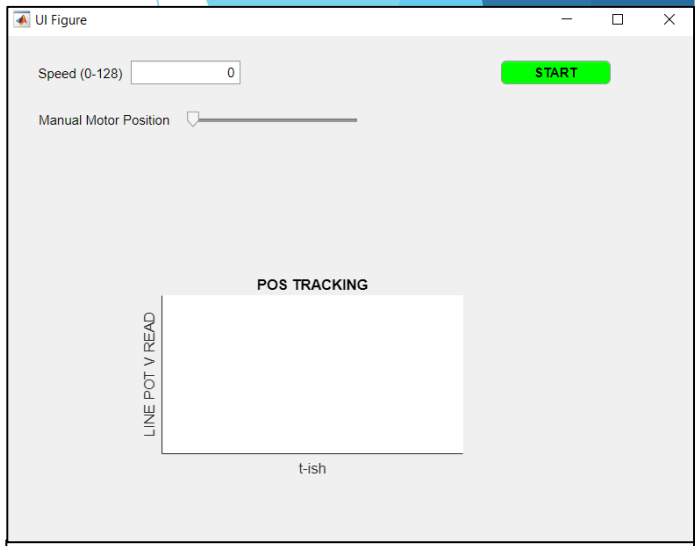
- Initial Choice:
  - Arduino Uno R3
    - Compatible with MultiMoto Arduino Shield.
    - Decided against because MultiMoto Arduino Shield used all pins on Uno
      - Needed more pins for linear potentiometers and on-board GUI.
- Final Choice:
  - Arduino Mega 2560
    - Compatible with MultiMoto Arduino Shield.
    - Same capabilities as Arduino Uno R3, but with more digital and analog pins.

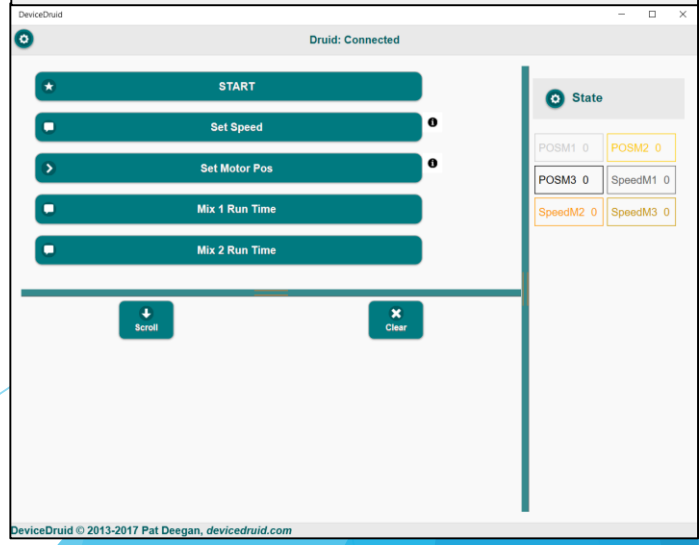


Graphic User Interface

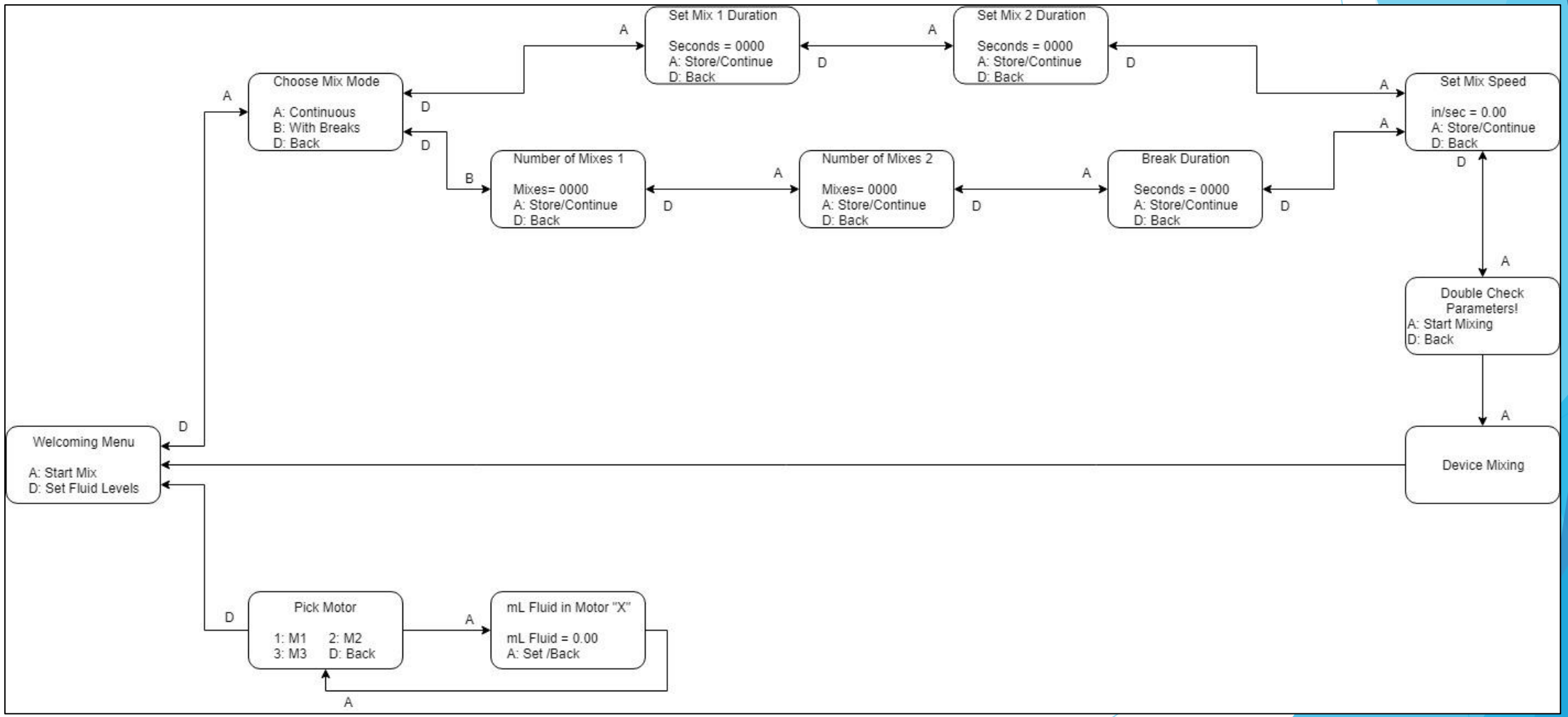
- Initial Choices:
  - MATLAB GUI – a PC-based GUI for Arduino control through a serial port connection.
    - Decided against because Arduino-support packages not exportable to standalone application.
    - User would be required to have MATLAB and run a script to control system – NOT user friendly.
  - Device Druid – another PC-based GUI.
    - Decided against because serial connection was unstable.
- Final Choice:
  - On-board GUI with LCD Screen and Button Pad
    - Does not look as fancy, but it gets the job done.





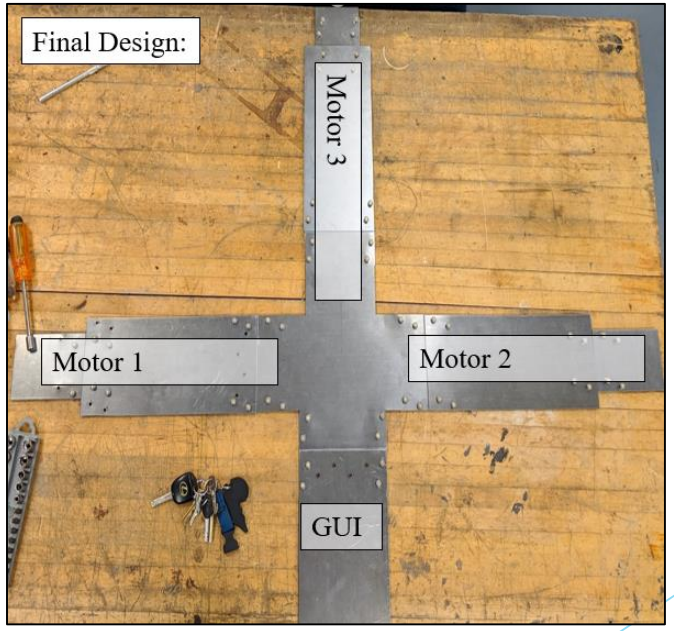


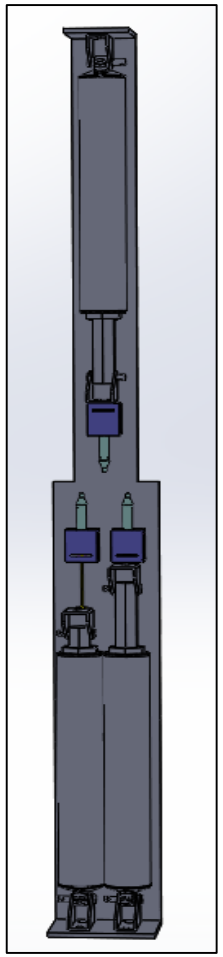
Graphic User Interface - Flowchart

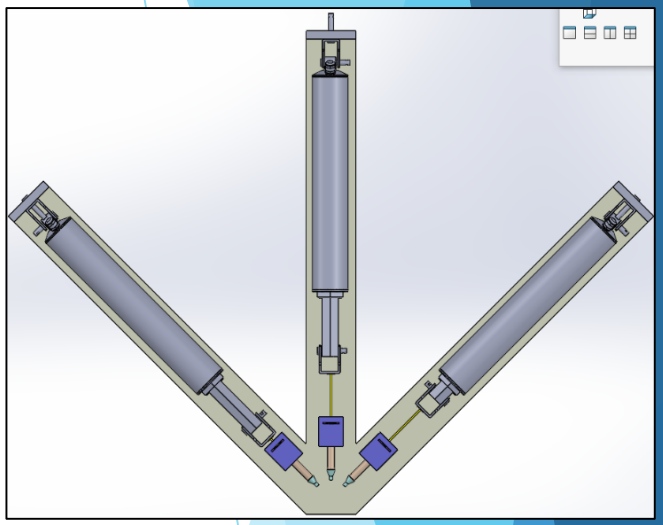


Mounting System – Motor Platform

- Initial Ideas:
  - T-Shaped Design – Uses a lot of space.
  - Chicken-Foot Design – No inter-syringe connector available.
  - Foldable Linear Design – Too much dead volume in inter-syringe connector.
- Final Choice:
  - Foldable T-Shaped Design
    - Allows least amount of dead volume.
    - Large area while unfolded.
    - About one foot by one while folded.
    - T made from cut sheet metal
    - Hinges at joints of T.

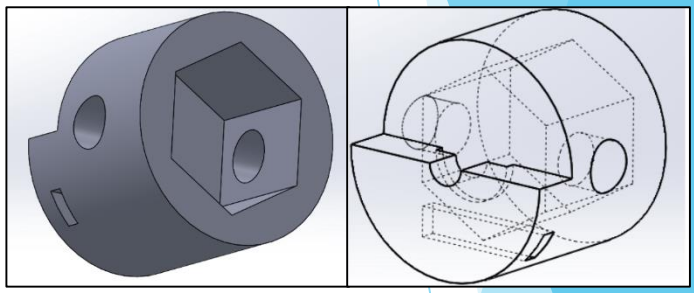


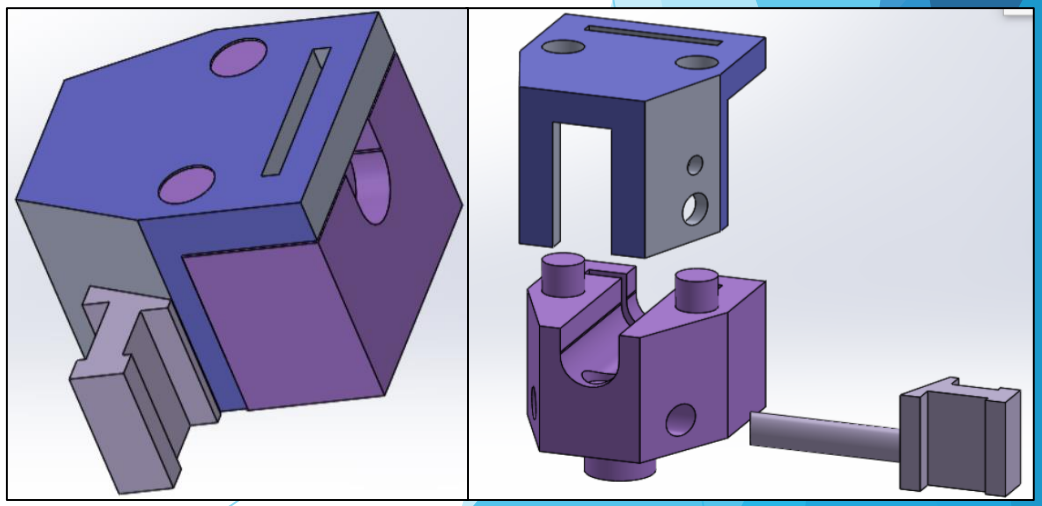




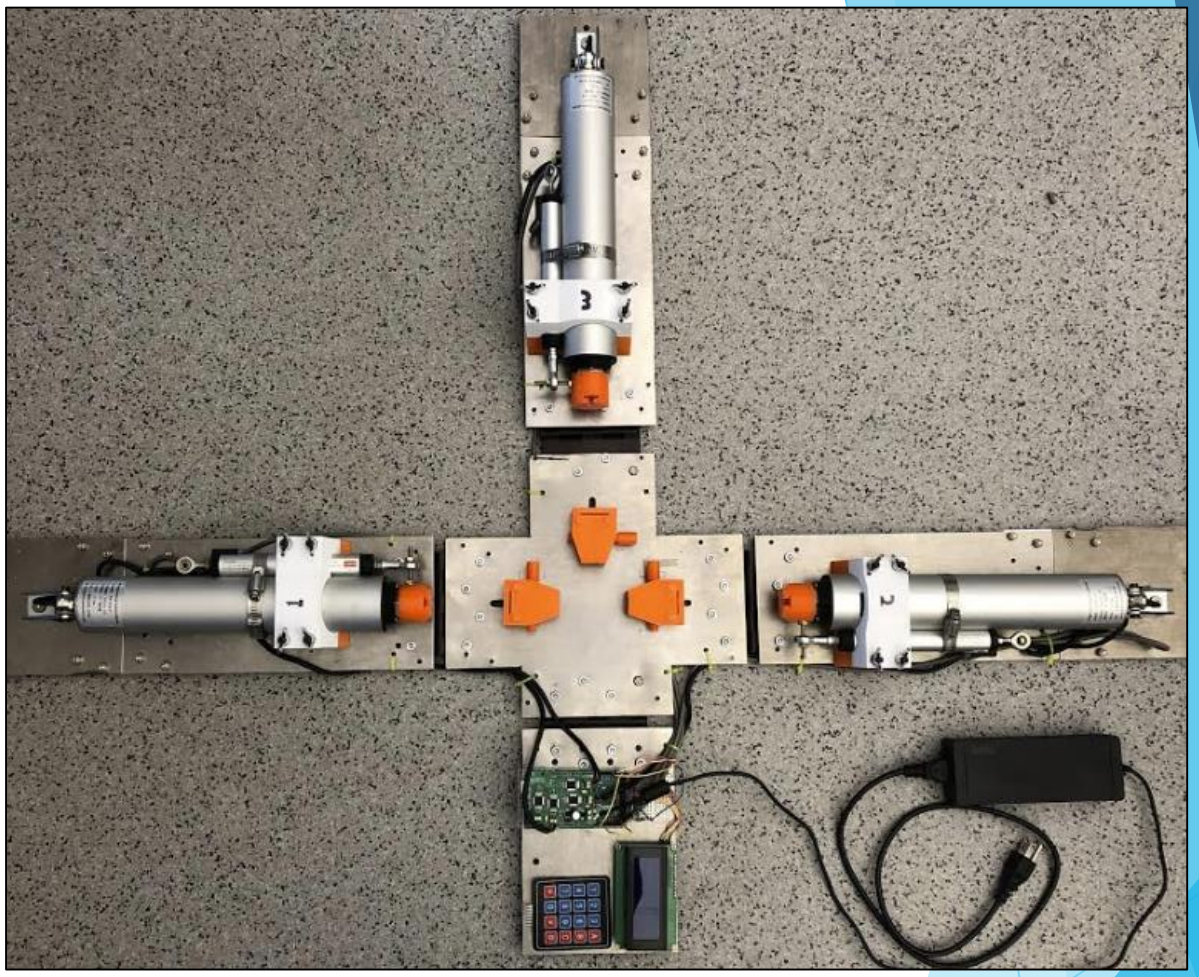
Mounting System – Syringe Mounts

- Syringe-to-Motor
  - 3D-printed motor piston “caps” with slots to insert end of syringe plunger.
  - Bolted to motor piston.
- Syringe-to-Platform
  - 3d-printed syringe holders.
  - Bolted to platform using holed drilled in center.
  - Easy-to-use cap and locking mechanism to secure syringes in place.





Final Product



- Max Speed: 9.00 inches/ second
- Min Speed: 2.00 inches/ second
- Position Accuracy: +/- 0.1 inch
- Speed Accuracy: +/- 0.1 inch/ second

- Current Flaws:
  - Motor 3 does not completely extend at lower speeds.
  - “Continuous” mix cycle causes much system movement at high speeds.

Future Improvements

- Improve GUI – smoother menu controls.
- Improve system stability while mixing.
- Consolidate total system area use.
- Hide wires.

Device Budget and Final Cost

Material	Description	Quantity	Cost	Total	
MultiMoto Arduino Shield	(Model: LC-82) - H-Bridge controller with four actuator allowing to conbtrol speed and current independently.	1	$48.99	**$48.99**	Used
12 Volt 2A Power Adapter	Supply AC to DC 2.1mm X 5.5mm Plug 12v 2 Amp Power Supply Wall Plug Extra Long 8 Foot Cord	1	$8.99	**$8.99**	Not Used
High Speed Linear Actuator	Model PA-15 - 4" stroke, 11lbs force, 9.05"/sec speed	3	$145.00	**$435.00**	Used
Arduino Mega 2560 Rev3	54 digital I/O pins, 16 analog inputs, and a larger space sketch	1	$27.00	**$27.00**	Used
LPPS- 22 Series Linear Potentiometer position sensor with rod end joints	Ruggedized Linear Potentiometer, Measure the linear motion or position of target with measuring range 0-4 inches.	1	$175.00	**$175.00**	Used
100-240V AC to DC 12V 10A 120W Power Supply Adapter Transformer	AC to DC 12 V 10A 120 Power Adapter	1	$18.88	**$18.88**	Used
LPPS- 22 Series Linear Potentiometer position sensor with rod end joints	Ruggedized Linear Potentiometer, Measure the linear motion or position of target with measuring range 0-4 inches.	2	$175.00	**$350.00**	Used
SunFounder IIC I2C TWI Serial 2004 20x4 LCD Module Shield for Arduino Uno Mega2560	LCD Display and I2C for the connection of the LCD to Mega	1	$12.99	**$12.99**	Used
Black Heat Resistant Rubber Pad Thin Silicone Grade Rubber Gasket Sheet 12 by 12 inch,1/25 Inch Thick	Needed for the vibration of the motors	2	$8.99	**$17.98**	Not Used
Mounting Brackets Set - 2 Brackets for PA-15		3	$17.00	**$51.00**	Used
12"x12" Sheet of Metal	The base of the device	4	$20.98	**$83.92**	Used
Bolts and Nuts	To secure the 3D prints and base components	1	$20.00	**$20.00**	Used
Matrix Array 4"x4" 16 Keys Keypad	User Interface to interact with the motors and GUI	1	$6.79	**$6.79**	Used
Elastic cords	Handles for carrying of the device	1	$2.23	**$2.23**	Used
3-D Printed Components	Syringe and Motor Holders	1	$87.63	**$87.63**	Used

Total Cost	**$1,346.40**
Budget Remaining	**$153.60**
Device Reproduce Cost	**$1,373.37**

Conclusion

Our Problem:

Aneuvas Technologies is developing a medication to treat Brain Aneurysms. Medication efficacy is directly correlated with the amount of energy imposed on the liquids during mixing, so the researchers cannot systematically produce samples by hand.

Our Goal:

Develop a clinical system to mix the three liquid medical components with reliable, user-defined, and continuously reproducible mixing results.

Our Solution:

The Three-Way Syringe Mixing Team has created a device capable of mixing between three syringes with speeds ranging from 2-9 inches/ second, with speed accuracy of +/- 0.1in/sec, and has positional accuracy of +/- 0.1in/sec.