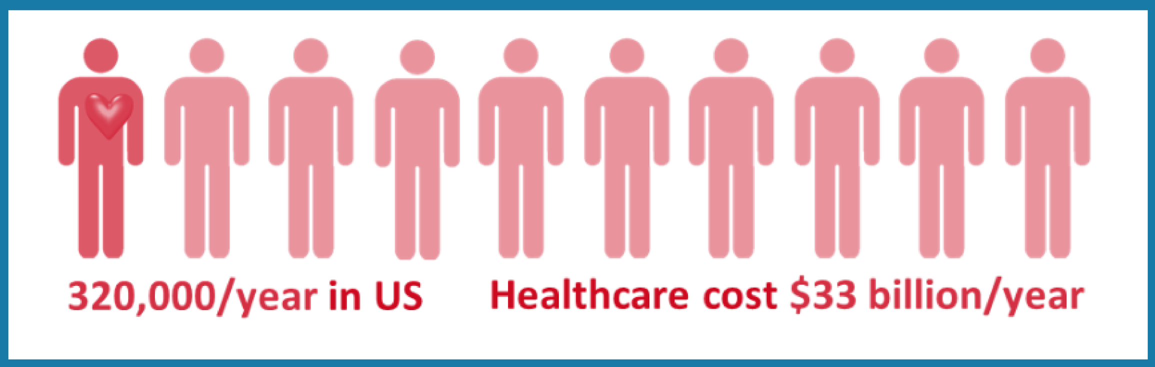
Medical rescue drone responds to cardiac events almost 9 minutes faster than EMS.

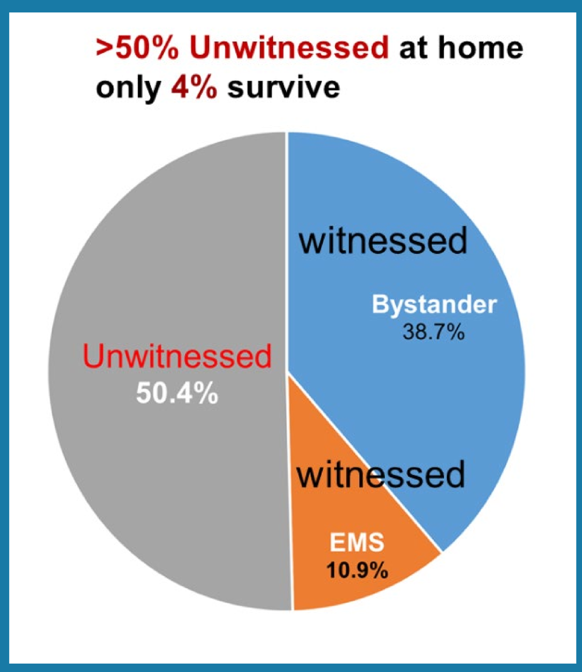
Thank you to Max Du for the use of his CWSF 2022 project as an example of the template. This a design example and not a direct copy of the project.

Why?

If our loved ones are undergoing cardiac arrest at home, they have two challenges:

1. They need immediate rescue since the survival chances are close to zero within 10 minutes. However, the average EMS response time is 9 minutes or longer in cities US/Canada, only 10.6% survive.
2. If they are home alone, only 4% survive. Among the 326,200/year OHCA (Out-of-Hospital Cardiac Arrest) patients in the US, 80% happen at home, over half are unwitnessed.





Currently, community medical bystanders are a worldwide solution by providing patients with CPR /defibrillators before EMS arrives, but only 38.7% of the arrest is witnessed by bystanders, and this solution is not applicable in rural, remote areas. In recent years, drones have been used to help save cardiac arrests. For example, a drone delivers AED (automated external defibrillators) in OHCA. These drones fly outdoors in cities or rural areas providing medical supplies but leaving the rescue to human rescuers. None of these drones are designed to help indoor patients directly.

The 10% low survival rate in the past 30 years is unacceptable, and current solutions are limited.

This is why I set out to innovate a Pre-hospital Indoor Rescue Drone to solve these two biggest challenges with goals:

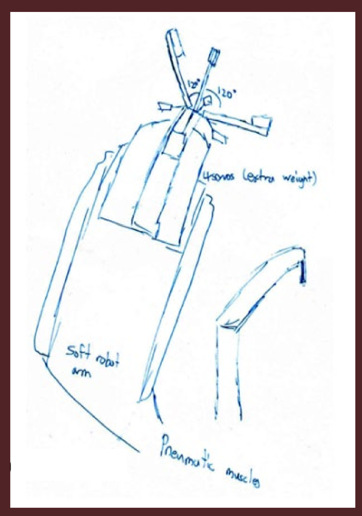
1. Start rescue faster before EMS arrives
2. Help save those patients home alone as well.

I hope to increase survival chances, shorten recovery times and reduce healthcare costs.

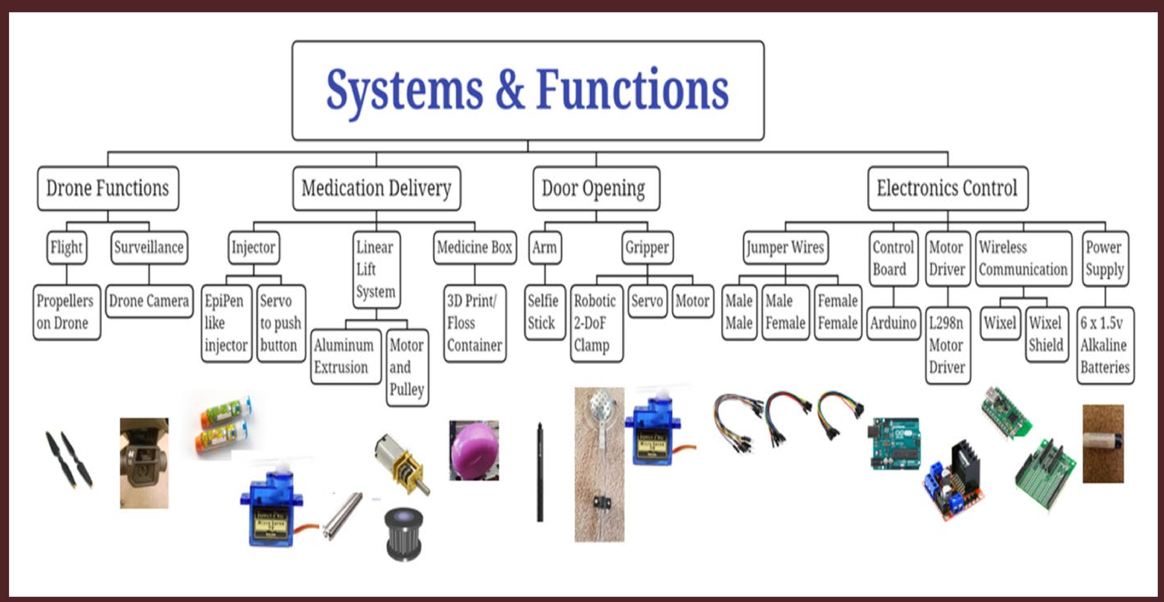
How?

Step 1: Develop Design Criteria and Conceptual Design
Based on my Preliminary Designs, three doctors and four engineers were consulted for professional insights and advice. I worked out the Design Criteria and Conceptual Design.

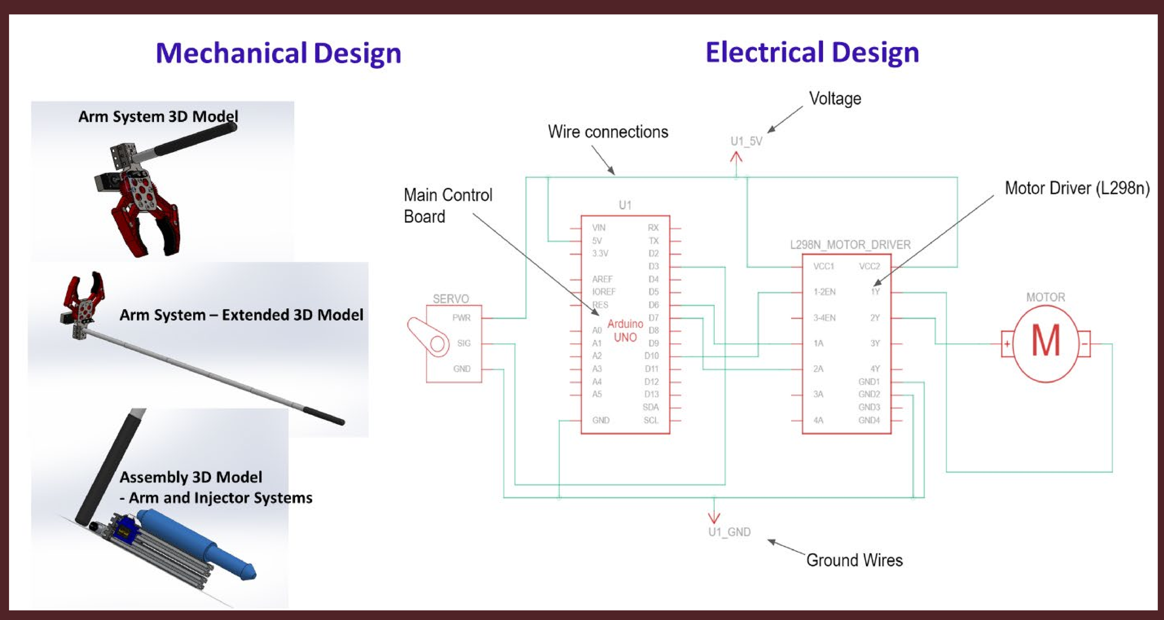
- **Design solution to the immediate rescue challenge**
  - Locate and approach patients in seconds, upstairs or downstairs.
  - Emergency Medication Delivery
- **Design solution to unwitnessed cardiac arrests**
  - Enable surveillance connection with EMS team through live video
  - Open room doors



Step 2: System-level Design
The design has four primary subsystems: drone, medication delivery, door opening, electronics controls.

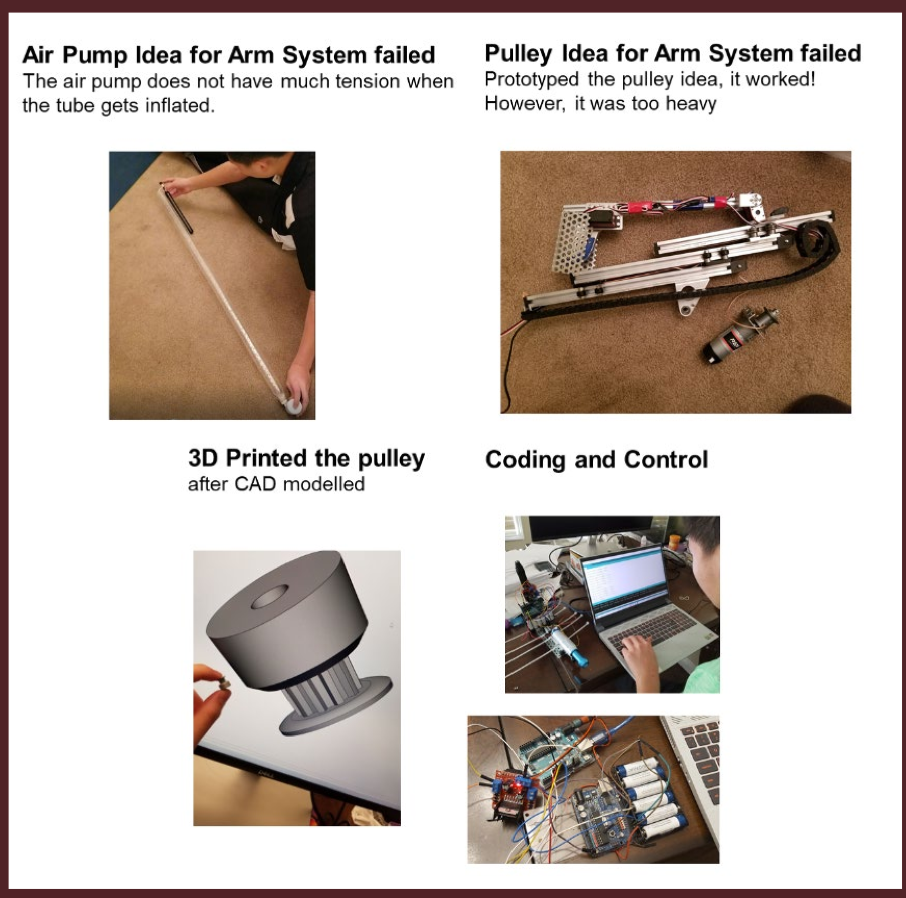


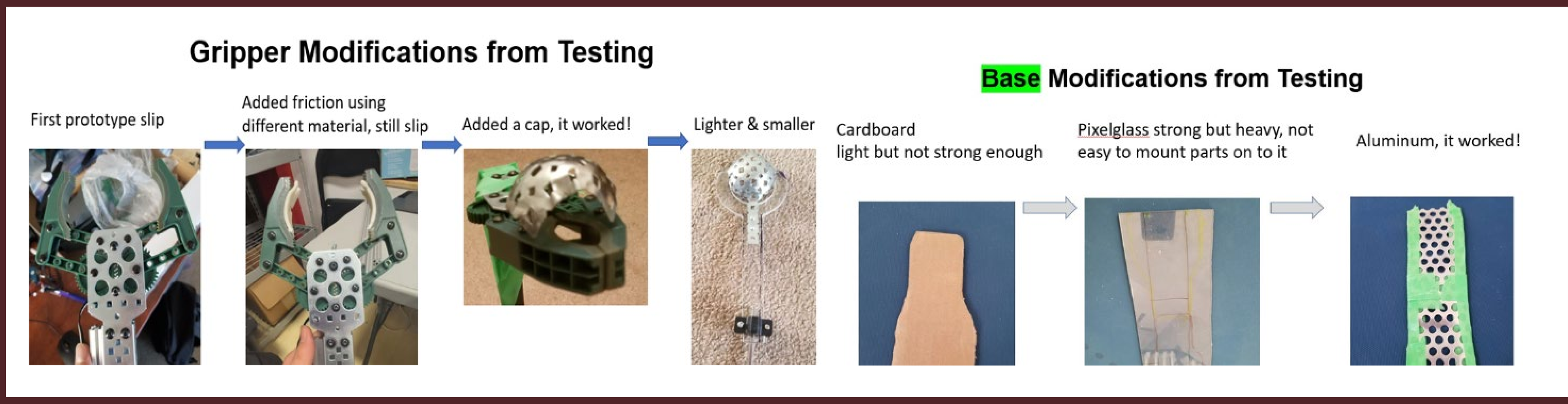
Step 3: Detailed Engineering Design - Mechanical and Electrical
Designed three auto-injection designs, four arms, and three grippers. After functionality comparison, low-fidelity testing, the arm system designs were either too heavy to fly or ineffective in arm raising. But I refused to give up. I added a "cap" to the gripper, solving both the arm raising and the gripper support issue. To verify design feasibility, I made mechanical and electrical design drawings:



How?

Step 4: Prototyping, Testing, and Coding
The prototype was fabricated, tested, and coded iteratively until it worked. For example, the base and gripper were modified. Arduino IDE was used to create motor control sketches and code for Wixels. To solve the unbalanced flight issue, the equilibrium point of the assembly was calculated. For cost-saving, I have been resourceful to utilize existing materials. For example, I borrowed my mom’s selfie stick for the arm system, my dad’s camping air pump to test a design idea, my sister's floss kit for the pillbox.





What?

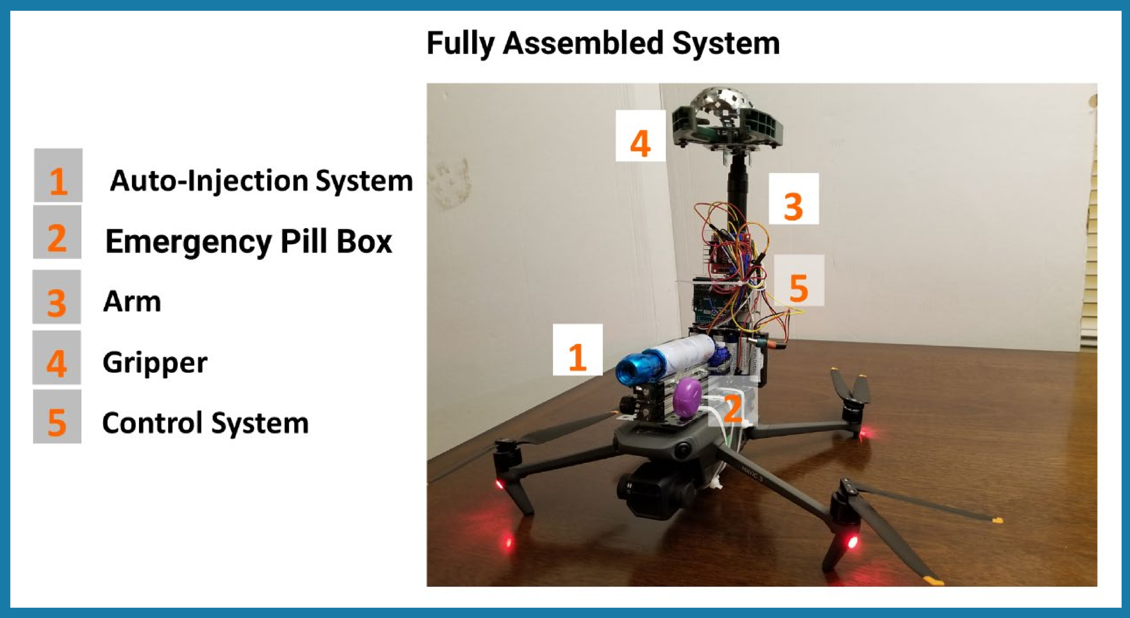
Currently, **the assembled prototype is automated and operational**.
The design is valid for:

1. Locating and approaching patients instantly
2. Emergency medication delivery with a pillbox and intramuscular auto-injector close to patients within an optimal distance for the auto-injection and close enough for the patient to reach the pillbox
3. Opening room doors through an extendable arm-gripper system

Drone Payload Test Result
The flight was balanced, and the drone was switched from Holystone to DJI Mavic 3 for the highest payload capacity 895g and flying stability, based upon the likely weight of the assembly which was calculated as 786g and much higher than the Holystone Drone payload capacity of 60g.

Solutions Comparison	Pre-Hospital Rescue Drone	AED Delivery Drone	Community Medical Bystander	EMS
Intervention Timing	- **Instant, 1-2 mins** flying upstairs in testing - Landed **average 3-6 cm from the patient**	- **2 mins faster than EMS** - Arrived within a median of **9 m from the patient**.	- **Varies** - Availability Not guaranteed	**≥ 9 mins**
Witness Coverage	- **All,** include patients home alone - **24/7 standby** - Provide EMS with **patient’s situation** and **precise indoor location**	- **Most effective in cities**, but not around high-rise buildings - Must in a controlled airspace for drone flying - Not dispatched during dark, rainy, or high-wind conditions	- **38.7%** - Not applicable to remote & rural areas	**10.9%**
Emergency Medication Delivery	- **Instantly** send prescribed **pills/injection** close to patient’s hands, potentially place a life-saving intervention directly in the hands of patients - **Deliver emergency medication to patients under surveillance,** an intramuscular auto-injection can be activated by an EMS team - **Personal prescribed** emergency medicine or any of general life saving - **Door opening design**	- Deliver **AED Defibrillator** to public location or drop **outside of a house** - **Require human rescuer** on ground to complete pick up and rescue	- **CPR** - Defibrillator (often with limited access)	**EMS rescue** and care

Improvements: Faster Rescue & Witness More Patients



Drone Locating and Approaching Patient Test Result - The drone instantly located and approached a person who collapsed on the 2nd floor of a house, by using “Return to Home” function of the drone upon the preset GPS coordinates of “Home Point” of the person, as tested within an average of 55 seconds.
- **Solved the "flapping" flight issue** which cost a pair of propellers.

Emergency Medication Delivery Test Result - After landing by the patient, the nozzle tip of the injector was **average 3-6 cm away, which is the optimal distance** for the auto-injection and close enough for the patient to reach the pillbox; the auto-injection was completed
- **Solved - Broken Injector Nozzle**
- **Solved - Broken Pulley of Injection**

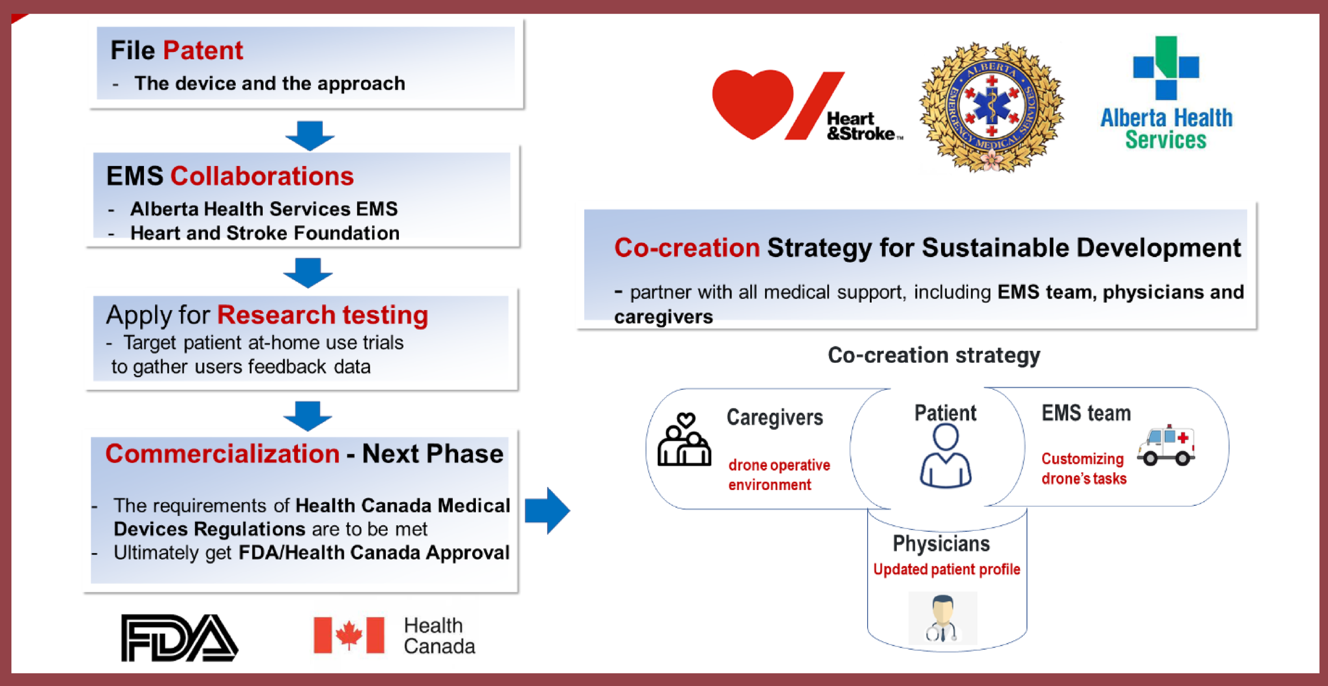
Door-Opening Test Result - Arm gripper system opened door by running the pre-programmed coding on my computer which could control the motor on the drone from a distance of 15m through the electronic control system via an Arduino microcontroller and two Wixels.

So What?

1. Making the World Healthier - Faster rescue and early patient surveillance before EMS arrives significantly enhance survival rates. Instant Emergency Medication Delivery within 6 minutes, increasing likelihood of recovery and reducing burden on healthcare system
2. Tool Can be Adopted by EMS system - Knowing patient situation helps speeding diagnoses and the precise indoor location helps locate patient faster
3. Great Commercial Potential - Fills market gap of cardiac arrest patients for faster rescue and early intervention, features can be expanded
4. Innovation Contribution - First indoor prehospital rescue drone designed to help save cardiac arrests at home, unique medication delivery under surveillance system, novel door opening system.

Ultimately, this innovation unlocks a novel solution for life-saving and expands unmanned aerial vehicles application for indoor emergency rescue.

What’s Next?



Thanks and References

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Software:
SOLIDWORKS, Flashforge, Femap, Nastran, Google Docs, Google Sheets, Pololu Wixel Configuration Utility, Arduino, PuTTy, Tinkercad