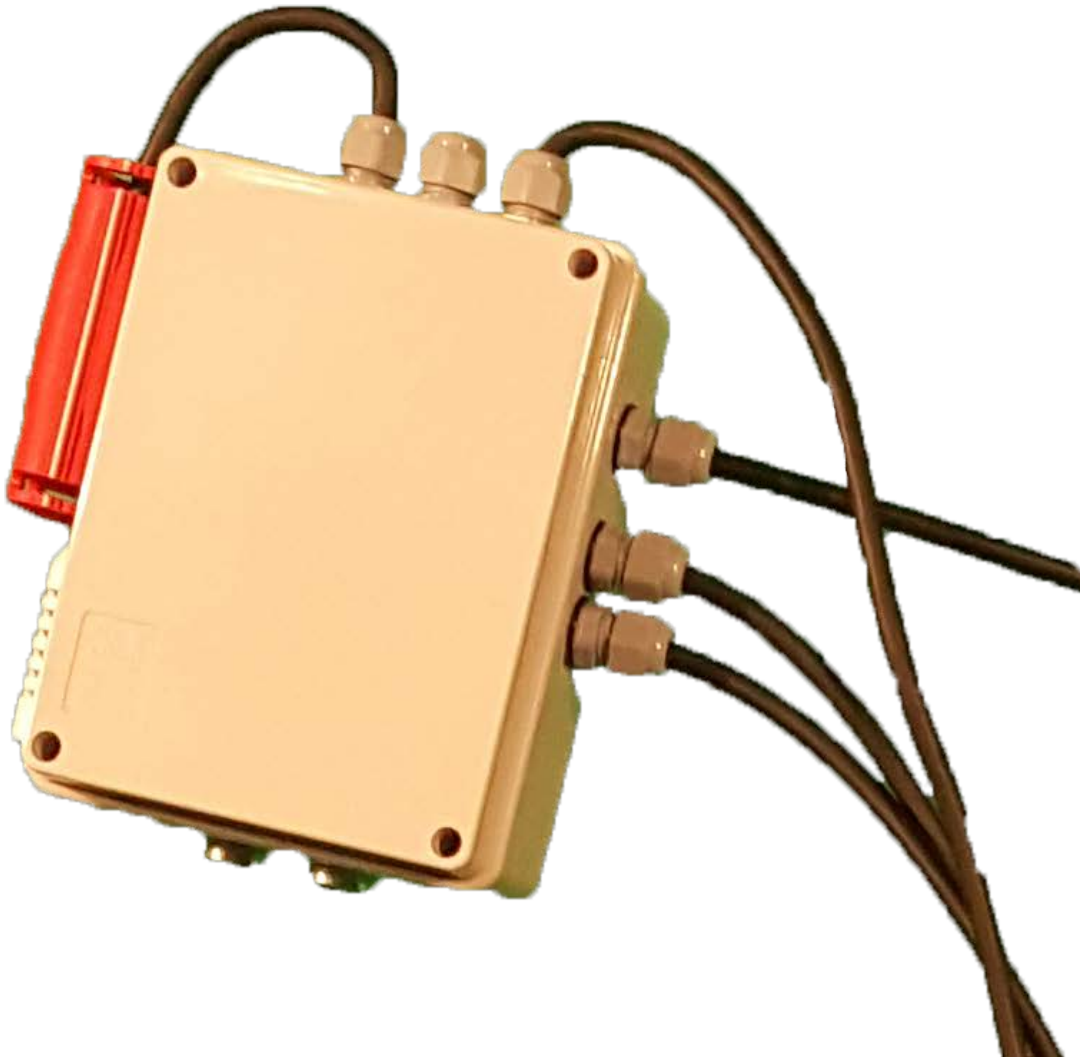
River-Nanny

The Nanny Which Look's After The River



By Donovan Weiss Webb

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Introduction

I have competed in the BT Young Scientist and Technology Exhibition for three years, the most prestigious contest in Ireland for under 18's. My favorite project from these entries is River-Nanny which is the subject of my maker's portfolio. I won the Analog Devices best in technology 2018 award for this project as seen in image 1.

River-Nanny is an automated river monitoring system which is installed on the River Vartry which runs through my property. It automatically monitors pH, conductivity, dissolved oxygen, water, temperature, ambient temperature and humidity. All this data is then transmitted to a server over the cellular network every hour. This is the only system that is capable of gathering so much data per day on the health of a river.

The concept of River-Nanny is to try and help to protect and improve the ecology of a river which is under stress from abstraction and other competing interests as shown in image 2. It accomplishes this by allowing scientists to review the data which helps to prove that some of these interests are harming the river. The data can also be used to support assumptions made of the effects of global warming. These subjects are very important to me because I live right by the river and walk my dog by it everyday. I can see that there is not nearly as much water as there used to be years ago, which is because the dam at the top of the river is taking 95% of the water. Global Warming is evident to the eye but there is no data to back this up. During heavy rain fertilizers run off the fields and are filling up the river. This is why I developed River-Nanny to try and protect the River Vartry.

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Donovan Webb receiving the Analog Devices Award for Technology at the BT Young Scientist and Technology Exhibition, Dublin, Ireland – January 2018

Analog Devices Testimonial

Donovan Webb,
East Glendalough School
Co. Wicklow,
Ireland

30th October 2018

To whom it may concern

This is to confirm that Donovan Webb, a second level student attending East Glendalough School Co. Wicklow, Ireland has been awarded the Analog Devices Technology Award for his project 'RiverNanny'. This award is presented to an individual or group for outstanding work exhibited in the Technology category at the BT Young Scientist & Technology Exhibition 2018 (see www.btyoungscientist.com).

The Analog Devices Judging team, led by myself found Donovan's project to be an excellent example of multiple sensors to cloud technology being used in an innovative way for the good of society. His project demonstrated an excellent understanding of sensor and interfacing technologies, embedded firmware and control and data to cloud implementations that are significantly beyond the gift or grasp of Donovan's peer student group.

In addition, we found Donovan to be a very engaged and enthusiastic innovator and technologist who has a great grasp of technology fundamentals and more importantly the intellect and ability to apply them. He is an excellent communicator, not only excelling in how he describes his project but also keen to describe some of the challenges he met on his project development journey and he how he overcame those challenges.

Analog Devices were delighted to host Donovan and his parents to our development division in San Jose, California as part of our technology award. While is San Jose, Donovan made a great impression on our wider engineering staff, presenting his project and anxious to learn more about leading edge silicon product development at Analog Devices. We are delighted and not at all surprised that Donovan is applying for a graduate program at MIT and on behalf of Analog Devices, I would highly recommend Donovan for any such program.

Brian O'Mara

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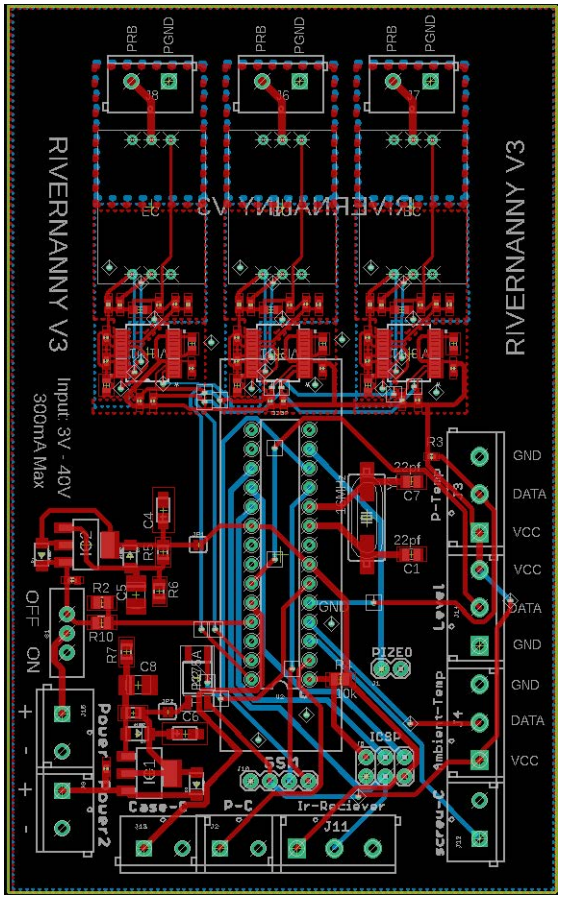
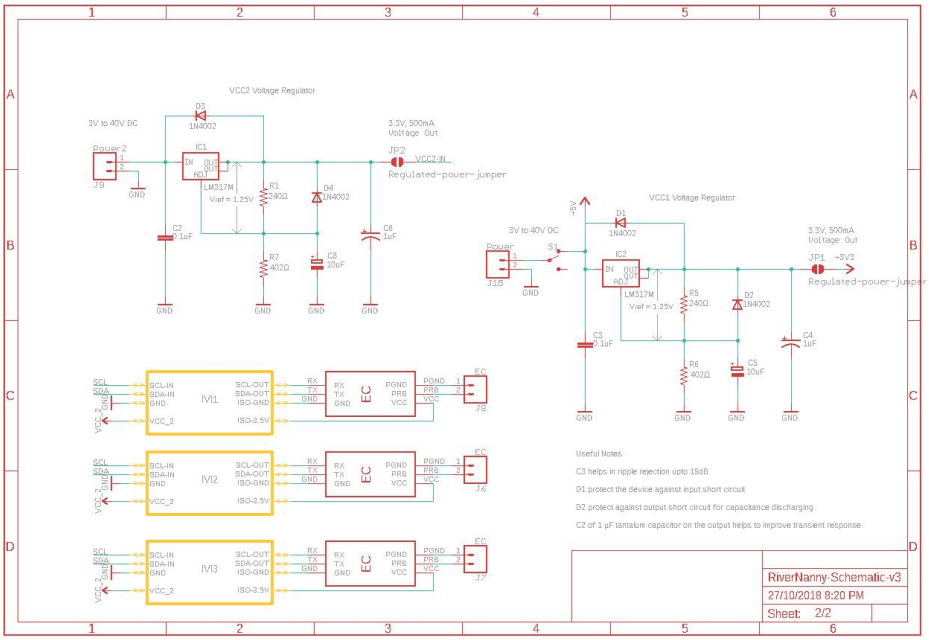
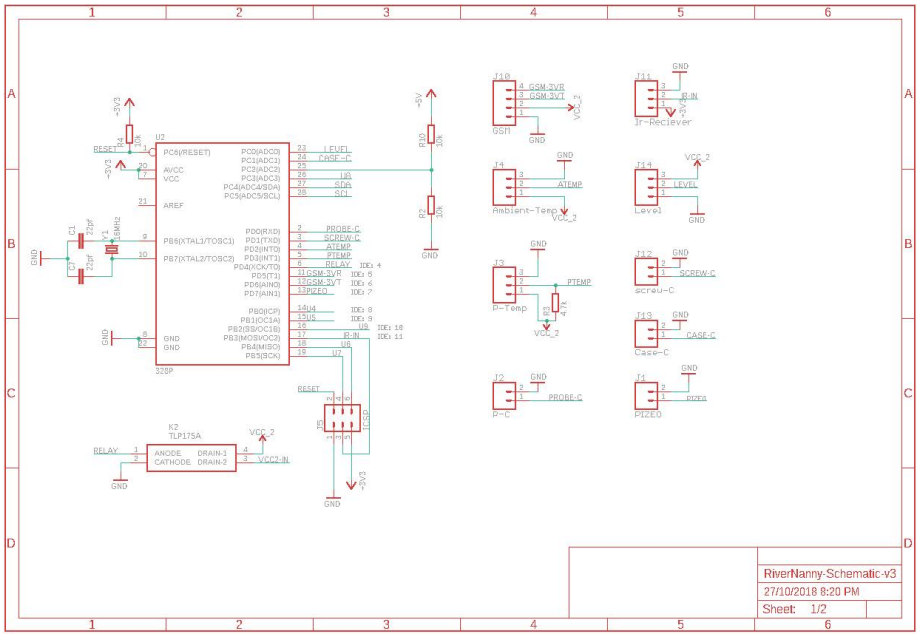
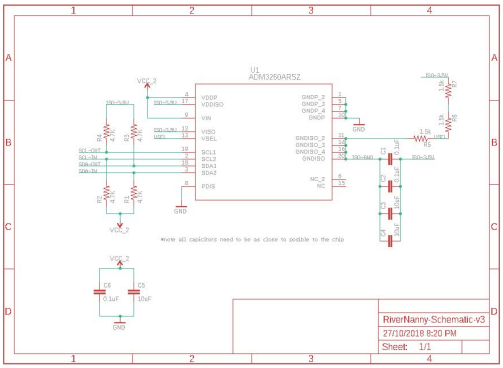
River-Nanny V3









Shown above are the PCB design and schematics for River-Nanny version 3. As you can see, it is based on a atmega328p which is the same chip which is in the Arduino Uno. I decided to design a PCB from scratch instead of using an Arduino. The requirements are to have to run off small batteries for years, an Arduino would use too much power. The PH, Conductivity and DO sensors are all very sensitive to interference which would not be suitable with an Arduino.

Another main design requirement was to have a low cost, low power solution. The only low-cost sensors which I could find were the Atlas Scientific sensors which are meant for laboratory use. Because of this they required a lot of protection especially as the pH sensor is made of glass. In order to protect them, I designed and made a 3d printed housing for them using ASA filament. It also made it more difficult to achieve the low power usage, as the control boards for the probes are meant to be always on which would use too much power. Instead, I wired up all the sensors to a relay in order to be able to power them down when they were not in use.

Another problem with these sensors is that they are extremely sensitive to interference. This means that each sensor requires a voltage isolator. The official atlas scientific voltage isolators are quite expensive so instead, I decided to design my own. On the PCB these three groups of components are just above the Atmega.

The reason I chose these data points to measure are because, the River Vartry is an EU salmoid river. The water quality specification is shown here. As you can see, River-Nanny measures the main specifications that can be measured automatically.

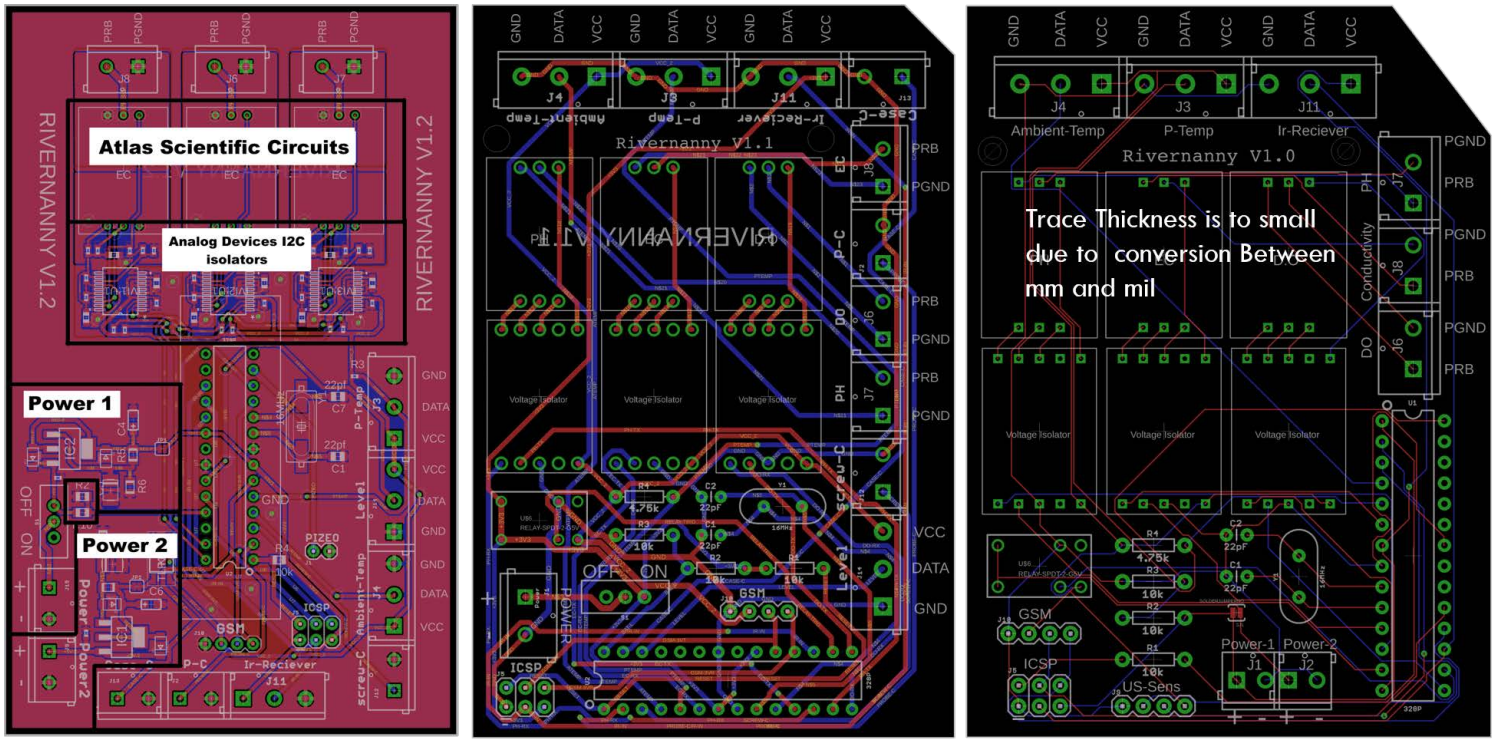
EU Specification for Salmonoid Rivers

Dissolved Oxygen	mg/litre O2	≥ 9
pH		≥ 6 ≤ 9
Suspended Solids	mg/litre	≤ 25
Temperature	°C	< 21.5°C , or 10°C, during the period from 1 November to 30 April where species which need cold water for

Although the EPA measures these monthly, the River Trust, who commissioned me, wanted the data in their hands and measured hourly or daily at many locations.

The advantage of this approach is that it allows us to install in many locations across the river which opens up other possibilities for example to be able to see where along the river harmful pollutants are being added. It also allows us to see how much of the water is being added by rain water by comparing to the meter near the dam and comparing this to rainfall data.

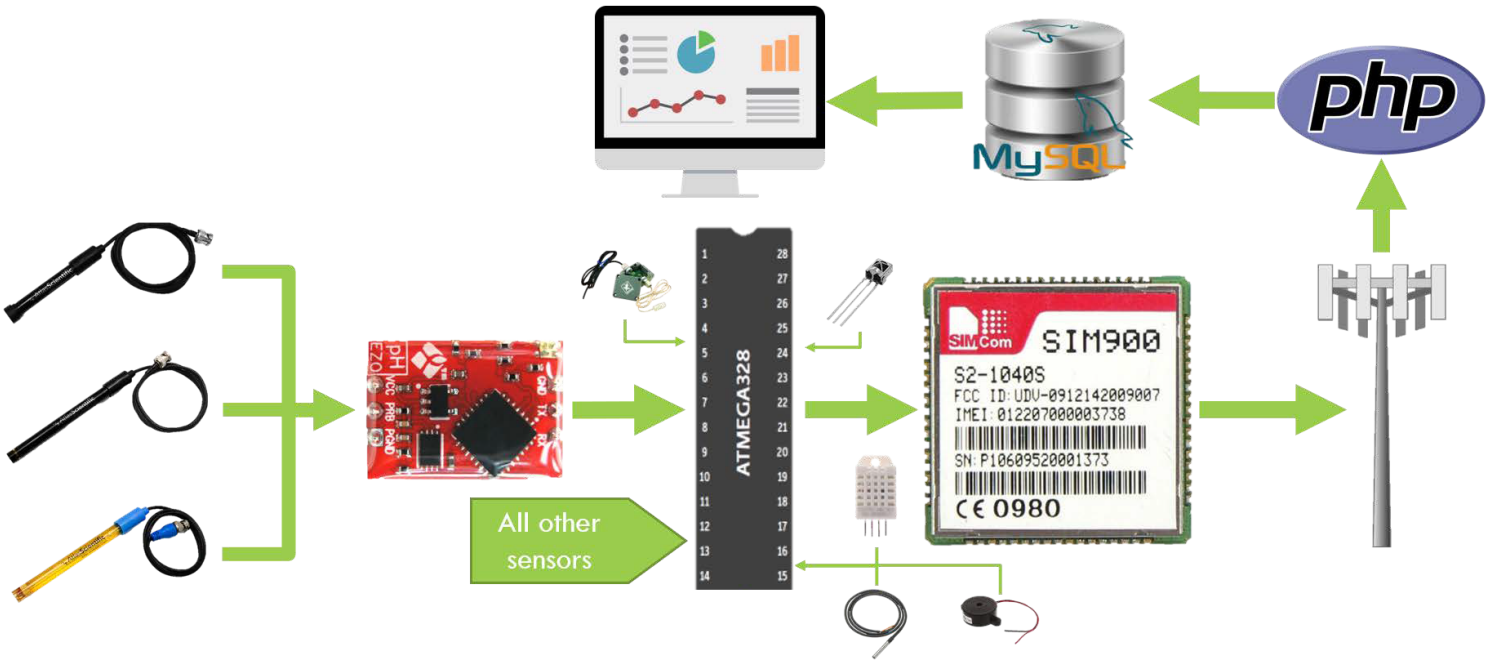
Evolution Of River-Nanny



Above are the three versions of River-Nanny. As you can see, the right PCB and the middle one is almost identical except that in the right one I used a really small trace width which resulted in the Atmega not being able to boot up. The middle PCB is the one which is installed in the river. there are some problems with it which is why there are a lot of jumper wires. The main new features between the middle one and left one is that I use custom voltage isolator circuits, a fixed relay, two separate isolated power systems, support for a zero force socket and significantly reduced interference.

With every version there is new code to be written. I use code to suit the purpose and write well documented code. I have the advantage of writing in many languages which I inherited from my father and then I have added some. River-Nanny is an ideal project because it requires exchanges of Arduino-language (C/C++) to AT Commands to PHP to SQL to HTML/CSS/ JavaScript. I haven't included code as the complexity of the project necessitates lots of code.

Putting It All Together



Shown above is the flow diagram of how River-Nanny works. In the center is the Atmega328p which is the core of River-Nanny connected to it is the IR receiver, ambient temperature and humidity sensor, water temperature sensor, a theft alarm, the controller for the capacitive level sensor and 3 atlas scientific control boards for the 3 atlas scientific sensors(PH, conductivity and DO). the Atmega gathers all the data from the sensor and stores it in variables. Then the data is compiled into a string which has all the data as PHP arguments. Then the ATMega sends the string to the GSM shield which calls an HTTP-Get request(goes to that website). Then it powers down everything, sets its alarm clock(a real time clock) and goes to deep sleep for an hour. On the server, the PHP receives the data and writes it to a MySQL database which can be viewed through a React admin panel.

All of this sits in a little box at the end of a pipe hammered into the riverbed, that protects the River Varty now and into the future. My vision is that all the rivers of Ireland, or even the EU, would have such a caring nanny looking after each of them.

Current Project

As always, I move from one thing to the next and I am currently working on my new project which excites me even more. In December my Grandfather has an exhibition in the Royal Dublin Society. From the invitation for the exhibition, "Kenneth's masterpieces of the past and vibrant new compositions will be displayed in harmony with new technology, such as virtual reality, to enhance the viewers experience of the art. Kenneth and his grandson Donovan, the 2018 winner of the BT Young Scientist's Technology Award, have worked together compelling Kenneth to embrace all the wonders of new technology. It has become a fusion of grandfather and grandson, and of art and technology, with beautifully unexpected results culminating in the Tec-Tank, a monumental interactive sculpture, inspired by Kenneth's enchanting paintings of poppies, that will wake and come alive when #KWFTecTank is tweeted."

At the center of the exhibition is the interactive technological sculpture called "The Tec-Tank". This fusion of art and technology. It involves 3 horsepower (2000 watts) of fans. Whenever someone approaches or Tweets #KWFTecTank, all the fans roar to life. This moves 10,000 silk poppies to dance in the 8' x 8' x 4' Plexiglas box which is the Tec-Tank. The tweet is immediately print on colored receipt paper and join all the poppies in their dance. This symbolizes the Technology, integrating and fusing with the flowers in order to create a spectacular sculpture.

The Tec-Tank uses 6x 500watt radial fans, 2x Fan controllers, 2x 10-amp circuit breakers, 2x relays, 1x Ardunio, 2x Raspberry Pi's and a receipt printer. When I first started working on the Tec-Tank, I vastly underestimated the aerodynamics involved. I thought all you had to do was throw four fans in the box and the flowers would flow in perfectly circular convection currents. From small scale test's, I soon realized that that is not the case. For example, if you had four fans equally placed in a line with a board above them, the majority of the surface area is dead-space (no moving air). I have discovered that if there is **any** dead-space anywhere in the Tec-Tank, all the flowers will fill that space until it creates a hopper looking shape into the fans. This eventually inspired the final design, which was to build 3 hoppers with two fans below each hopper. All of the Tec-Tank was sloped, which meant that there was no safe place for the poppies to rest. There are still some bugs to be worked out particularly the acoustic design or lack of it. This is planned to be addressed soon using egg carton insulation. This project is very different from any of my other projects because it involves little software, lots of machining and an aesthetic design, as well as aerodynamic engineering.

There is a lot more technology built into the exhibition but I only list these sub-projects. I have made 360-degree videos of walking with my Grandfather in his favorite painting locations that will be viewed on Gear VR Headsets at the exhibition. There will be a unique Virtual and Mixed Reality 3D painting experience which I have created. There are several Time Lapse videos of my Granddad painting hung along side these same finished paintings. I also designed and built an automated Auctioneer with a big red button and an annoying noise whenever someone bids. I also created several Video Walls displaying the time-lapse video's that loop automatically using a Raspberry Pi Zero. I am finishing programing both an IOS and Android app for a more interactive exhibition catalog.

Conclusion

I am fortunate and thankful that I have all the ability's that allow me to undertake the projects that inspire me. I chose to make the subject of my maker's portfolio about River-Nanny and touch slightly on my new project. I have done many projects like Professional websites for charities and disabled, apps, automated polytunnel system for organic growing, tourist app for tree recognition, robotic simulation, 3d printer, robots and youth computer mentoring.

I am also good at getting the knowledge as I still need to learn more and get better at what I do, so I can work on important projects. I have applied to MIT because it offers the widest opportunity anywhere in the world. As a High School senior, I have limited time and often there is a conflict between my studies and my projects and the necessity of setting priorities. My priorities are sometimes ordered by my interest and my schoolwork suffers. What I can say, is that I am a true Maker and get immersed in what I do. I have taken this literally, and fully immersed myself in my new project!