Drone Racing

Preshil MYP Personal Project 2017

Sam Heeps

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Introduction/Criteria A: Investigating

A 'drone' by definition, is a UAV (Unmanned aerial vehicle) or remotely piloted aircraft. This may be in the form of a missile, aeroplane or helicopter/multirotor.
My goal was to build a drone, capable of racing and competing in events, then entering an event and racing (and not coming last!)
Before commencing this project I had no prior knowledge of the sport, but I soon realised that there was a lot more that needed to be done. Partly due to how much time I realised this hobby required, my Personal Project has become the main use of my time, I find myself spending sometimes hours per day researching for new technology, how-to's and learning new information.

My global context is Scientific and Technical Innovation, and I selected this because I believed it fitted best with my Goal and overall project. High performance quadcopters and FPV (first person view) multirotor racing is an extremely new sport and there are always new innovations and ever changing laws surrounding this sport. In addition to this, drones and multirotors are being used for the first time ever in agricultural scenarios, being used by the military as a new form of combat and becoming an effective way of transporting goods to disaster zones. They are also becoming a part of our daily lives such as providing, for example, postal services, surveillance and food delivery. It is due to these reasons that I believe that there would be a relationship between my goal/personal project and global context due to the fact that this technology is being used to shape the way that our world will be in the future and providing solutions for problems arising in society.

I had heard of the sport from my mum, who had a colleague's son who was active in the sport. Before commencing this project, I did not have an understanding of the large amount of research to be done before beginning the development process. The amount of research, preparation, time spent, money and technical ability that was required were all things that I soon learned. As this is a DIY hobby, there isn't a large amount of documentation and instructions associated with any specific product that is available for purchase. Assistance came from forum websites and local sources who I began to find once I began flying, and in a lot of cases these sources ended up being extremely helpful. There are a lot of small things that you need to know which may not be known to the naked eye, or without

exploring a large amount of online websites, web articles and product pages. The sources listed in my bibliography only account for some of the hundreds of websites that have been of use to me during this process. In total, I believe that I spent at least 100 hours alone researching and beginning to practice in simulators before beginning the development process of my Project.

As shown in Appendixes 1 and 2, my sources mostly came from videos and web articles which were fairly inconsistent, and at some times didn't provide the information necessary to be of any assistance. Therefore, for most products or electronics which I bought, I used a standard 'pin out' diagram showing what pads and holes on the electronics do what and where things need to be connected. As I became more knowledgeable and gained a general understanding of the electronics used, trial and error was mostly used along with these diagrams, eliminating the need for resources such as video tutorials or long blog posts.

Criteria B: Planning

The criteria that I had chosen for my Project were fairly simple, in which I have a set budget of $250 for my initial build, with aspects such as the transmitter (controller) and goggles (to pilot the drone in FPV) were excluded from this budget. Other criteria includes the quadcopter must be suitable for racing, and for it to be completed by the deadline (first race) where I would have the skill to complete the course. In Appendix 3, it shows my criteria and why I have chosen these points, such as choosing a carbon fibre frame over a plastic one (the rigidity and little extra weight compared to plastic combined with more conventional mounting and toughness makes it a clear option) and the need for my drone to be race legal so it conformed with the Australian Civil Aviation Safety Authority rules and regulations as well as the club's. In Appendix 4, I begin to talk in my Process journal about how I intend to complete the project and what parts I need to think about buying to build my quadcopter.

As I had a set deadline to adhere to to have the quadcopter ready for my first race, my intention was to do as much planning / research / practice to race before the 1st meet, which was the Melbourne Multirotor Racing Club's 3rd round of the season on March 19th, 2017. This began with planning of my budget and what I needed to get started and complete the track, where I quickly discovered the price of the items and parts required were much more expensive than my original $250 budget. In total, with the remote and FPV goggles I realised it would cost about $1500 to start. From there, with the new idea of

expenses in mind, I began researching as much as I could about the parts which I intended to use (Evidence of this is shown in Appendix 5, where I plan and state what parts are required to build my quadcopter and the obstacles that I may face when building or tips to not harm electronics in the build process). About 3 weeks after beginning my Personal Project, I made contact with Kai, the kid who my mum had known who also participates in the sport. He was happy to sell parts for my first build second hand, and assist in the building process.

About 2 weeks later after talking to him (1st week of September) I met with Kai, and he taught me some of the process involved in building the quadcopter myself, and also provided assistance or knowledge where necessary. I purchased the carbon fibre frame, the flight controller, motors, speed controller, radio receiver and video transmitter from Kai for $215. Then, I purchased the rest of the parts required, such as the camera, antennas and propellers for another $60, with the total quadcopter build coming in at $275 (excluding batteries), which is not too much over the original $250 budget. From this point, I was then able to get in the air and begin learning how to fly the quadcopter. I had been advised by Kai to start in the standard mode - 'Acrobatic' mode. This means there are no assists or corrections being made by the flight controller on the quad so all movements it was making was by me moving the sticks. This way, the learning curve was extremely steep as I slowly understood how to hover, how the control sticks make the quadcopter behave and began to be able to complete basic maneuvers, such as flying around trees or doing figure 8's on the oval.

I believe starting this way was a good choice, as it meant from an early point in my learning I was doing it the correct way and not learning bad habits from flying with modes that corrected the movements in my sticks.

During Christmas Holidays on the 10th of December, I went away for 6 weeks so was unable to further develop and continue my task, giving me 2 months to get ready for my race meet when I returned. I was lucky enough to come across a small number of local pilots in my area, such as Fasial, Tung, and Brett, who were further able to help me develop my understanding of how different flight tricks and maneuvers worked, help me learn how to fly through gates (thus being able to complete a track) and were also able to assist with direction of new, more advanced hardware and maintenance of my drone, such as new

motors for extra power or different propellers for better speed and control/handling in the air. By this point, I had a greater understanding of how everything worked, as I had had to disassemble/reassemble my quadcopter for repair after crashes and installation of new hardware which greatly helped my confidence in making repairs by myself and allowed me to fly better as I knew the limitations of the hardware which I was using (or install newer gear which allowed me to, for example, perform better acrobatic movements, increase control, become race legal for my first event and go faster).

As I begun to fly with others rather than just by myself beginning February 2017, I also became more aware of the laws and restrictions surrounding where I could fly, such as keeping a 30m distance from roads, buildings and people, but also allowed me to watch other people fly who were much better than me,m learn new maneuvers and fly better. Some of the local people also had practice gates and flags, which is what is used as a racecourse, so I was able to practice flying through gates and going around a course before my first race day.
On the 19th of March 2017, the time came for my first event - Melbourne Multirotor Racing Club's 3rd Round which is in Wantirna South, Victoria. Entrants are divided into divisions based on skill, hence I was in Division C, which is the lowest class, as this was my first race.. All pilots have 1 battery (approx. 2-3 minutes) to practice the course, then will commence the race which is 3 laps of 4 pilots each, and first to complete all laps wins the race.
And I didn't come last! In fact, I did extremely well for my first event. I was able to complete the track with relative ease and came 1st in 1 race, came 2nd in my second and didn't finish my 3rd race heat. The field of competitors in C division being fairly small this was enough to make it to the Finals where I came first in my grade. This event was largely the completion of Criteria C and B as I had used my plan and research effectively to the set deadline.

The number of obstacles that I had to overcome in this project was quite large. The initial learning curve to even begin to understand all processes and electronics involved. And, of course, crashing, then the rebuild process (where something may not have worked) or having to wait to order parts off the internet, as there is only 1 walk in store in Melbourne, which is quite far away from me. Other obstacles included learning new skills, such as soldering and repair, and others were more practical challenges such as getting to flying

locations (as most involved a 30+ minute car ride), having time to practice with other priorities in the week (I play tennis 3 times a week in between schoolwork), and organising after school activities to fit in with flying. In most cases, racing was a fairly low priority, meaning I was not flying a lot during a week, so I used the opportunities when I could fly to the fullest.

Criteria C: Taking Action

The product that was created from my research was fully capable of all criteria which was: the drone was race legal- meaning it had suitable 5 inch props, was powered with a 4 cell battery and output legal 25mw (milliwatt) video transmitting power as per the club's rules. The drone could perform all acrobatic maneuvers, was built of carbon fibre and was able to keep up with all other race drones on the field at the time. My product also shows a relationship with the Global Context (Scientific and Technical Innovation) as 6 months ago the technology advancement and software that I have used to build my drone was non existent to the public. This same technology that we are using is the same that is being developed for agriculture, delivery, military and other applications that drones will be used for in the future, albeit on different scales for the different purposes. Since my first build of my quadcopter, I have upgraded and modified it to keep up with other drones and improve its performance based on recommendations from other people and seeing first hand different improvements others have made to increase performance. I have also built 2 other drones since then, utilising different, lighter frame designs more tailored for high speed racing which I would use to compete with in the future instead of my original build which was intended as a 'freestyle' frame, meaning it was larger, heavier (albeit more durable) and less desireable for racers. I would also use all 3 of these quadcopters to compete in the Australian Drone Nationals held on the 7-9th of July 2017.

My product also fully reflected my goal in which I stated I would build a drone capable of racing, which I then used to enter a number of local and interstate events. The original product (before modification) was not used to compete as I had modified it before then to be able to keep up with the other quads on the racetrack. Pictured in Appendix 6 on the left is the original quadcopter with a newer build on the right used more specifically for racing. This project/hobby requires a lot of research into each individual part, and forces you to learn about each of them and how they can work together, with the pros and cons of using different parts and cause/reason for things not working. From the start of the project, I was fairly 'closed-minded' about what my product would be (as I knew from the start I

wanted my product to be a race drone), hence in Appendix 7 I have not especially documented my thought process about what my product will be, but I have discussed different parts that will work better/different combinations of parts to achieve better performance, durability or maneuverability.

To learn about the hobby solely by reading information is extremely hard(as there is no central resource), in my experience it has been extremely beneficial to get out and meet others nearby who share an interest in quadcopters. This was done whenever I went to race or practice meets, local fun fly's in my area I have always learnt something new to try, different products or software to use and general skill tips to improve my flying asking from another person's experience has always been more helpful than reading articles on the internet. I'm now also a member of many different Facebook groups from around Melbourne and around the world where people are able to share questions and information and I have been able to share my experience and knowledge in return.
In my process journal - Appendix 9, I have written about my experiences with my local club Movement Melbourne, which includes people such as Fasial, Brett, Tung, Alex and Harry who are some of many who have helped me out in this project, providing invaluable resources and information for me, such as spare parts (generally for a greatly reduced price if not free), or help and instruction when building or replacing electronics.
Aside from Movement Melbourne, there is an extremely large community of 'miniquad' pilots in Melbourne, surpassing over 1000 members of the large local race groups whose members are mostly extremely active on forums and Facebook, which is where a large amount of the information and help is shared between people as it is very easy and quick to send replies and share photos, videos and sell parts. Included in Appendix 8 is also a photo of me on the starting grid with other finalists from the Australian Drone Nationals. Pictured from left to right is Owen Littleton from Perth, Australia, then Sam Heeps (Me) Ross Kerker from Sydney and Thomas Bittmatta from Melbourne. I feel like this is a good photo as it represents the hundreds of people that I have met and made friends with and shared information with along the way, who which now I am able to share the experience and enjoyment of the sport with.

Criteria D: Reflecting

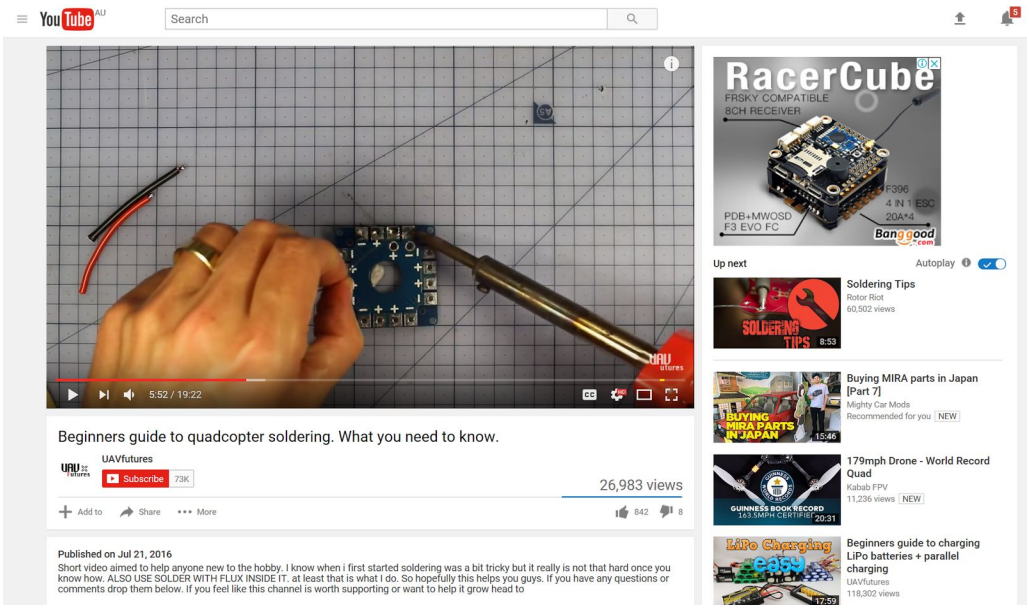
In total, my criteria was achieved except that I had spent more money than originally planned. My original criteria was to spend $250 on the whole project, which I soon discovered was not possible. To the point of fulfilling the project (the first race at Melbourne Multirotor Racing Club) I had spent approximately $1500. This included all tools required to repair my quadcopters, such as a soldering station and any tools required. My product met all criteria, which meant it was made of carbon fibre and was able to compete in races, something which I learned was not really possible with the original budget I had planned for this project, but the extra cost involved has also allowed for the quadcopter to be extremely more durable, repairable and nicer/more enjoyable to fly, something that would not have been possible with the initial budget that I had set in mind before understanding the real costs behind the hobby which I learned quickly.

Through my project, I have learnt and better developed the skills of researching, persistence and determination but I have also learnt how to solder, to work with fragile electronics, aspects of coding in C++ and writing scripts and design, although I could have better worked on my time management (for the MYP side of the project) when writing this report and writing in my process journal, which I could have done more often and included more detail with, something I did not write about in my Reflection in my process journal.

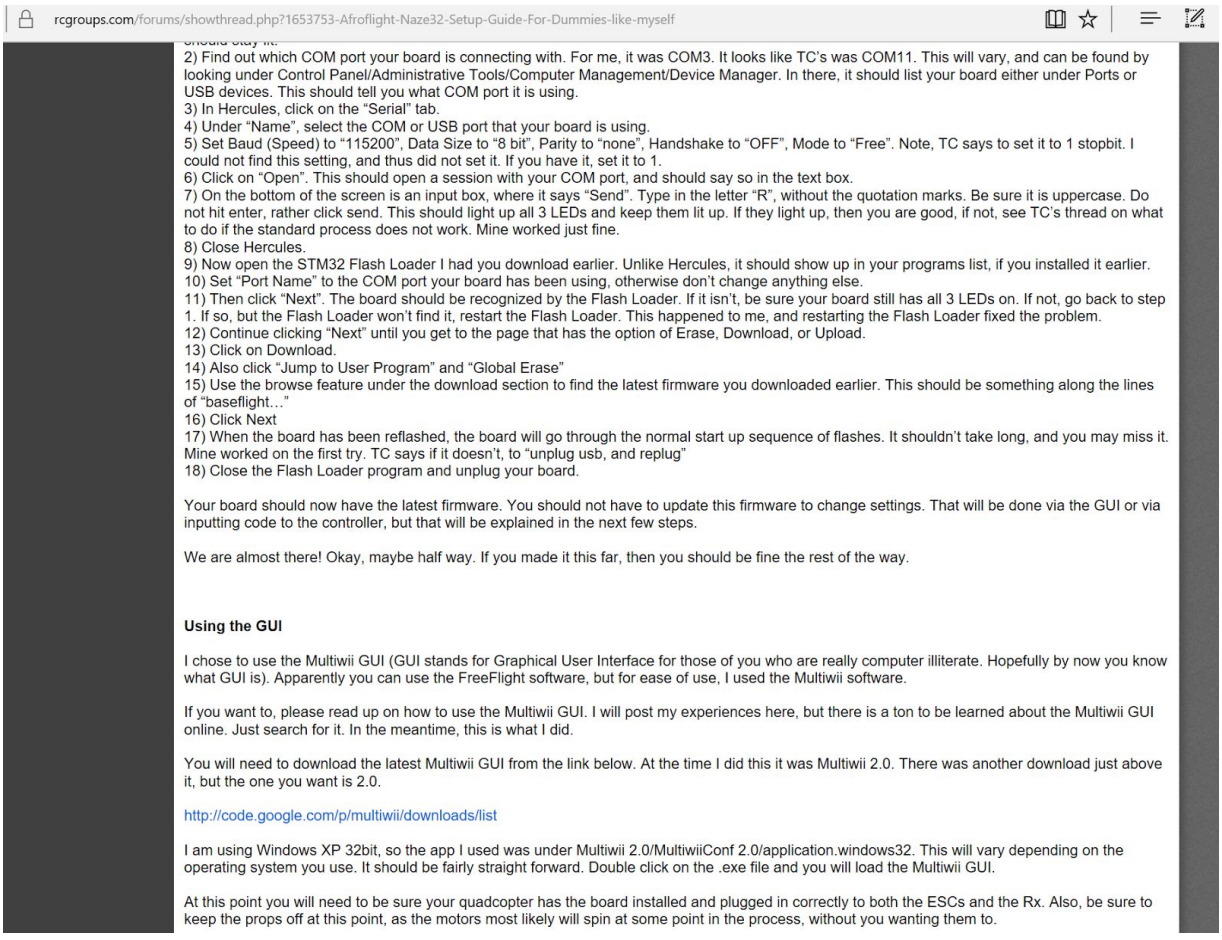
The project has made me completely understand the topic - I believe I have spent well over 500 hours researching, building, flying, learning from other people. Even though the project was difficult, the nature of the topic and the relationship with technology and electronics made it something that I enjoyed thoroughly, to the level that this project has become more than the MYP Personal Project for me, it is now another sport, another interest and passion in my life. I am also able to compete to a high level in the sport now - I am completing in A / 'Super' class races now and I have just been to the Australian Drone Nationals 2017 where I came 3rd in Australia (out of the entrants). In Appendix 10, I reflect on what I have learnt, which is almost everything I know about the hobby today. I walked into the Personal Project with little idea of what processes were involved in Drone Racing and now am an active part of the community who is able to contribute knowledge to discussions and pass the information that I have learnt onwards. I also have to say thank you to my mum for her constant support throughout my project, she has been able to drive me to allow me to fly at events, provided immense financial support and the time she has spent waiting or helping me to which I am extremely grateful.

Appendices

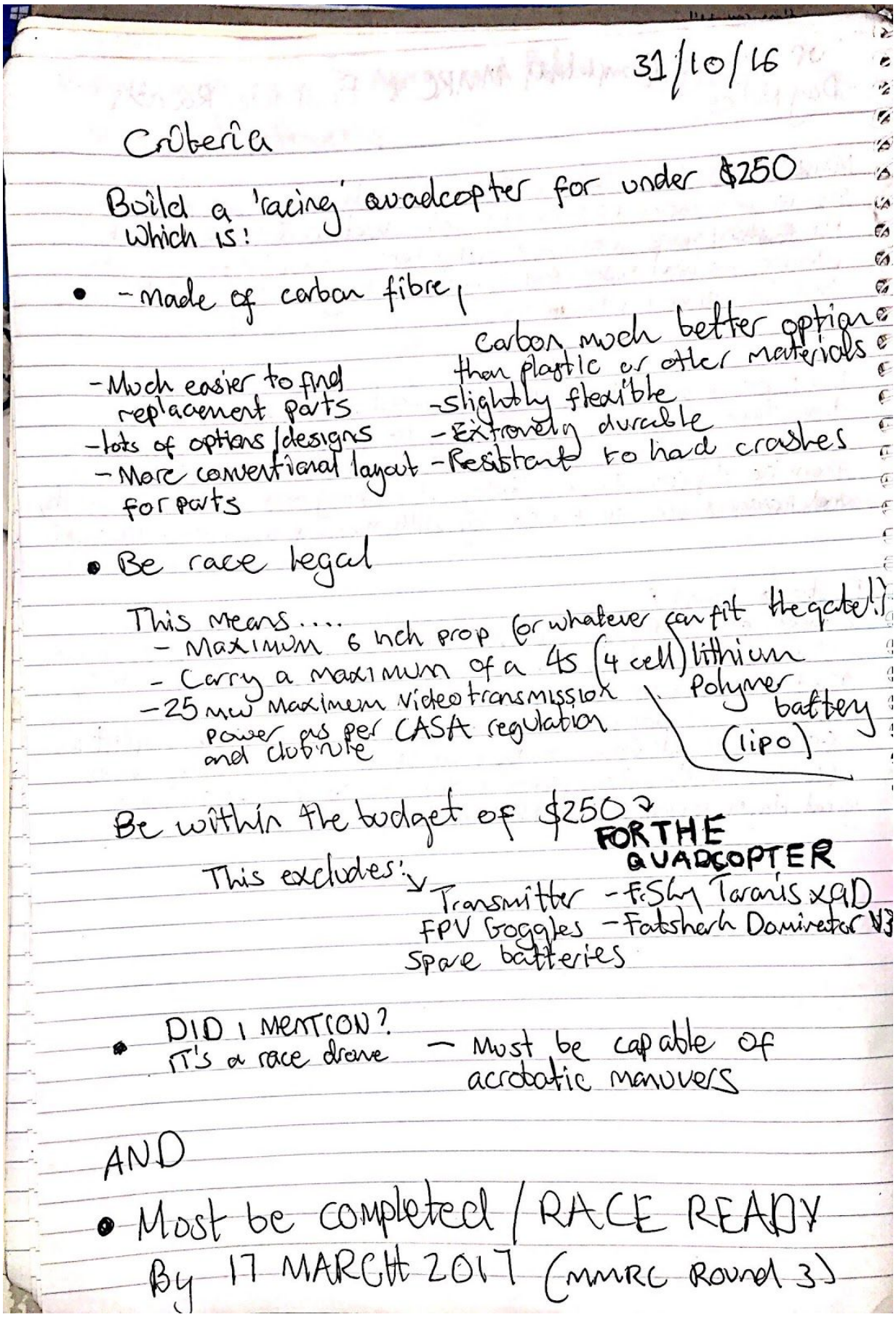
Appendix 1 Research skills



Appendix 2 Research skills



Appendix 3 Evidence of criteria for product/out come



31/10/16

Croberia

Build a 'racing' quadcopter for under $250 which is:

- made of carbon fibre,

carbon much better option than plastic or other materials

- Much easier to find replacement parts
- lots of options/designs
- More conventional layout for parts
- slightly flexible
- Extremely durable
- Resistant to hard crashes

- Be race legal

This means....
- Maximum 6 inch prop (or whatever can fit the gate!)
- Carry a maximum of a 4S (4 cell) lithium Polymer battery (lipo)
- 25 mW Maximum video transmission power as per CASA regulation and club rule

Be within the budget of $250 FOR THE QUADCOPTER

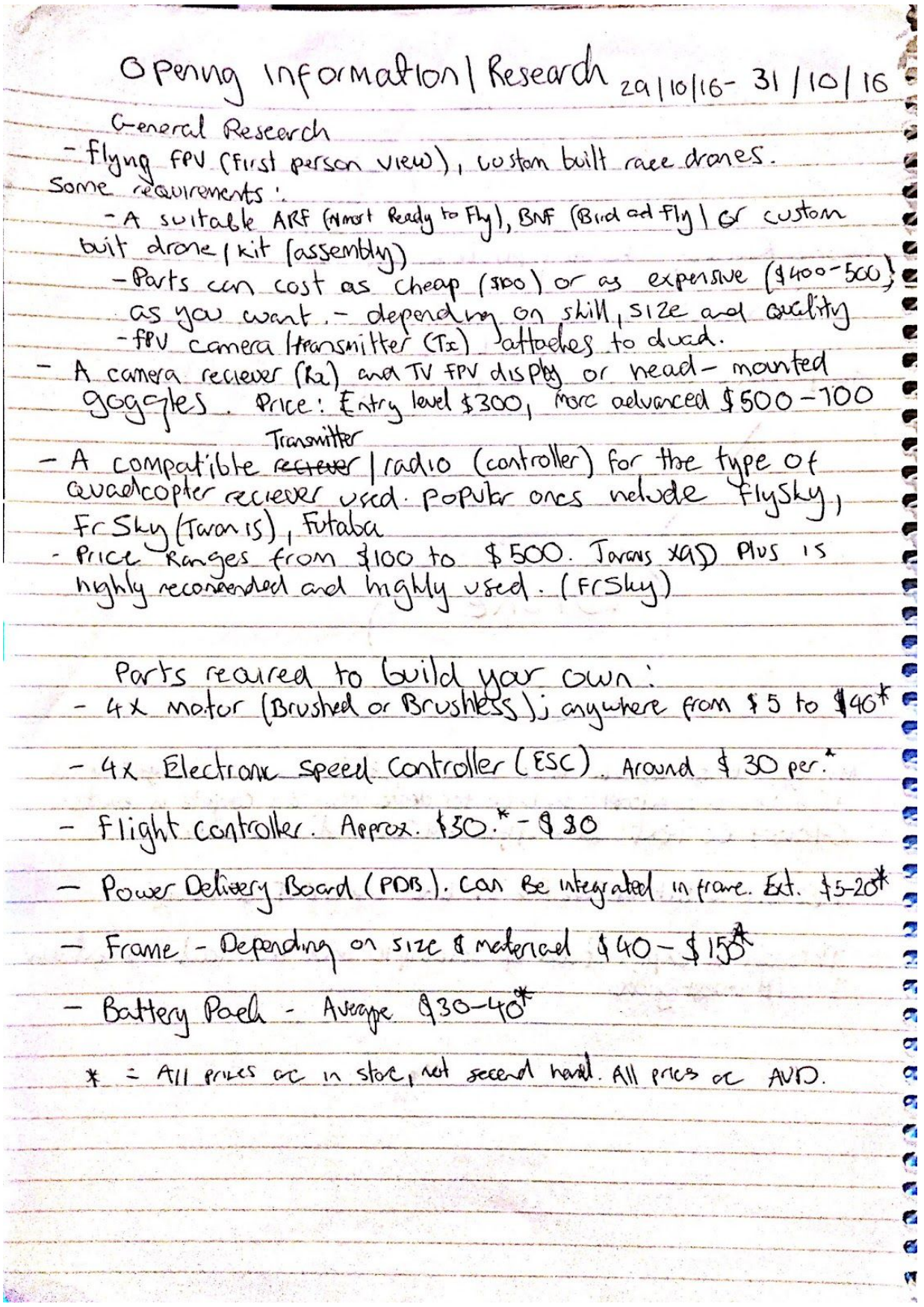
This excludes:
- Transmitter - FrSky Taranis x9D
- FPV Goggles - Fatshark Dominator V3
- Spare batteries

- DID I MENTION? IT's a race drone — Must be capable of acrobatic manuvers

AND

- Most be completed / RACE READY By 17 MARCH 2017 (MMRC Round 3)

Appendix 4
Timeline of planning



Opening Information | Research 29/10/16 - 31/10/16

General Research

- Flying FPV (First person view), custom built race drones.

Some requirements:

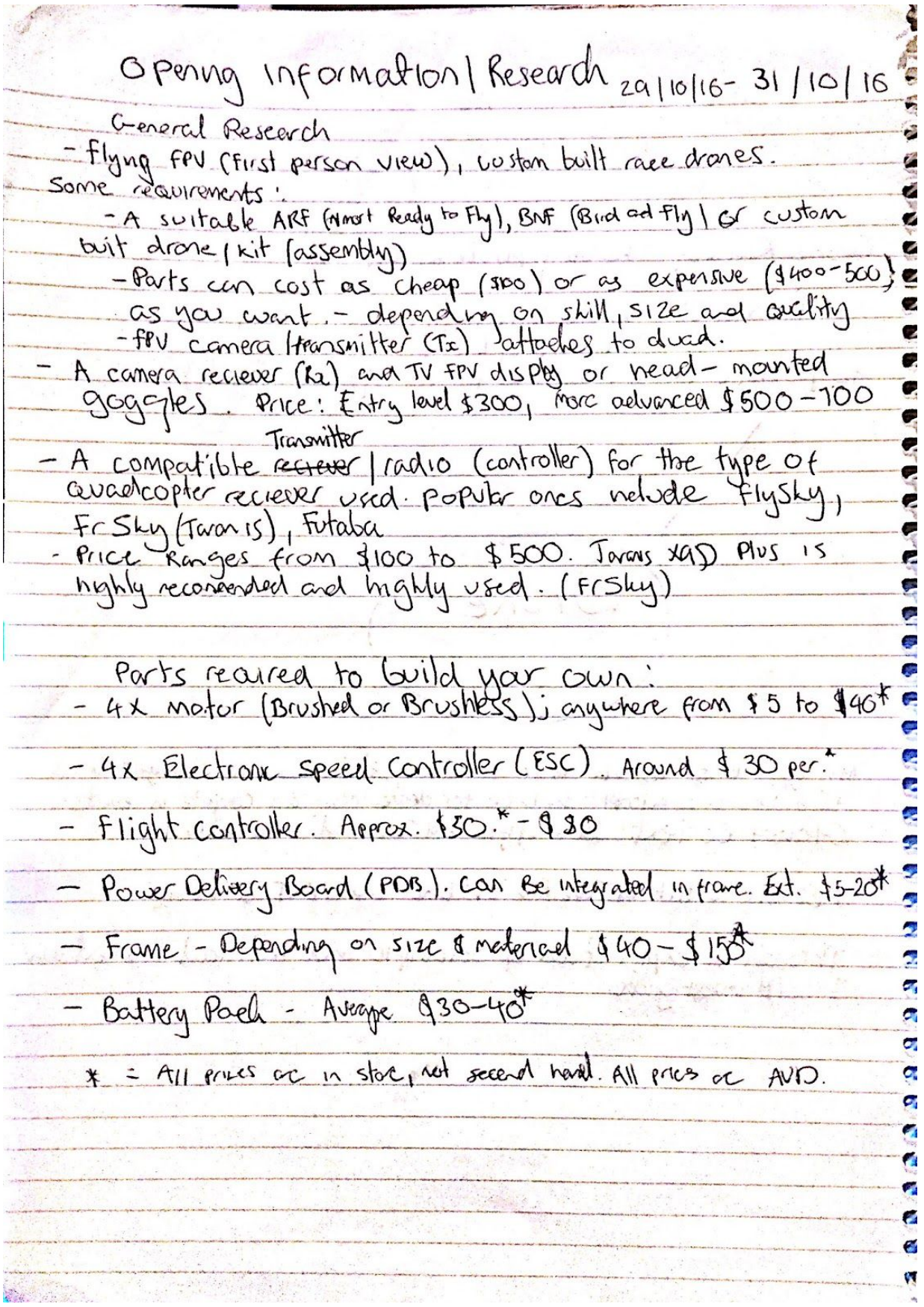
- A suitable ARF (Almost Ready to Fly), BNF (Bind and Fly) or custom built drone / kit (assembly)
- Parts can cost as cheap ($100) or as expensive ($400-500) as you want. - depending on skill, size and quality
- FPV camera / transmitter (Tx) attaches to quad.
- A camera reciever (Rx) and TV FPV display or head-mounted goggles. Price: Entry level $300, more advanced $500-700
- A compatible ~~reciever~~ Transmitter / radio (controller) for the type of quadcopter reciever used. Popular ones include FlySky, FrSky (Taranis), Futaba
- Price Ranges from $100 to $500. Taranis X9D Plus is highly recommended and highly used. (FrSky)

Parts reqired to build your own:

- 4x motor (Brushed or Brushless); anywhere from $5 to $40*
- 4x Electronic Speed Controller (ESC). Around $30 per.*
- Flight controller. Approx. $30.* - $80
- Power Delivery Board (PDB). Can be integrated in frame. Ext. $5-20*
- Frame - Depending on size & material $40 - $150*
- Battery Pack - Average $30-40*

* = All prices are in store, not second hand. All prices are AUD.

Appendix 5
Self management skills



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Appendix 6 Evidence of product		

Appendix 7
Thinking skills

Understanding Specifications - cont'd

Video Tx's

A typical video transmitter on a quad may operate at different power levels, for different ideal environments. Many racing quadcopters will choose a VTx capable of operating at 25mW, as this is the reccommended standard for races as to not interfere with other quadcopters transmissions in close proximity. These VTx's may be capable of switching to a higher power level (ie 200mW or 600mW) for better quality video during solo flights or flying through areas with lots of interference i.e buildings with concrete, walls or RF saturated areas.

What is legal in my country?

Power level legalities vary in different countries, as do operating frequencies (2.4 ghz, 5.8GHz, 433mHz, 1.2ghz, LRS systems). In Australia it is legal to operate video transmission with a 25mW power level.

ESC Batteries - cont'd

A lithium-Polymer battery (LiPo) can have a varying number of cells wired in series inside a pack to allow a higher voltage and a higher performance battery.

Small quadcopters, such as the eachine are able to use 1s (1 cell) batteries, as the motors are relatively small and current draw is low. It is also possible to use 2S (2 cell) batteries to achieve better performance.

PEN SWITCH

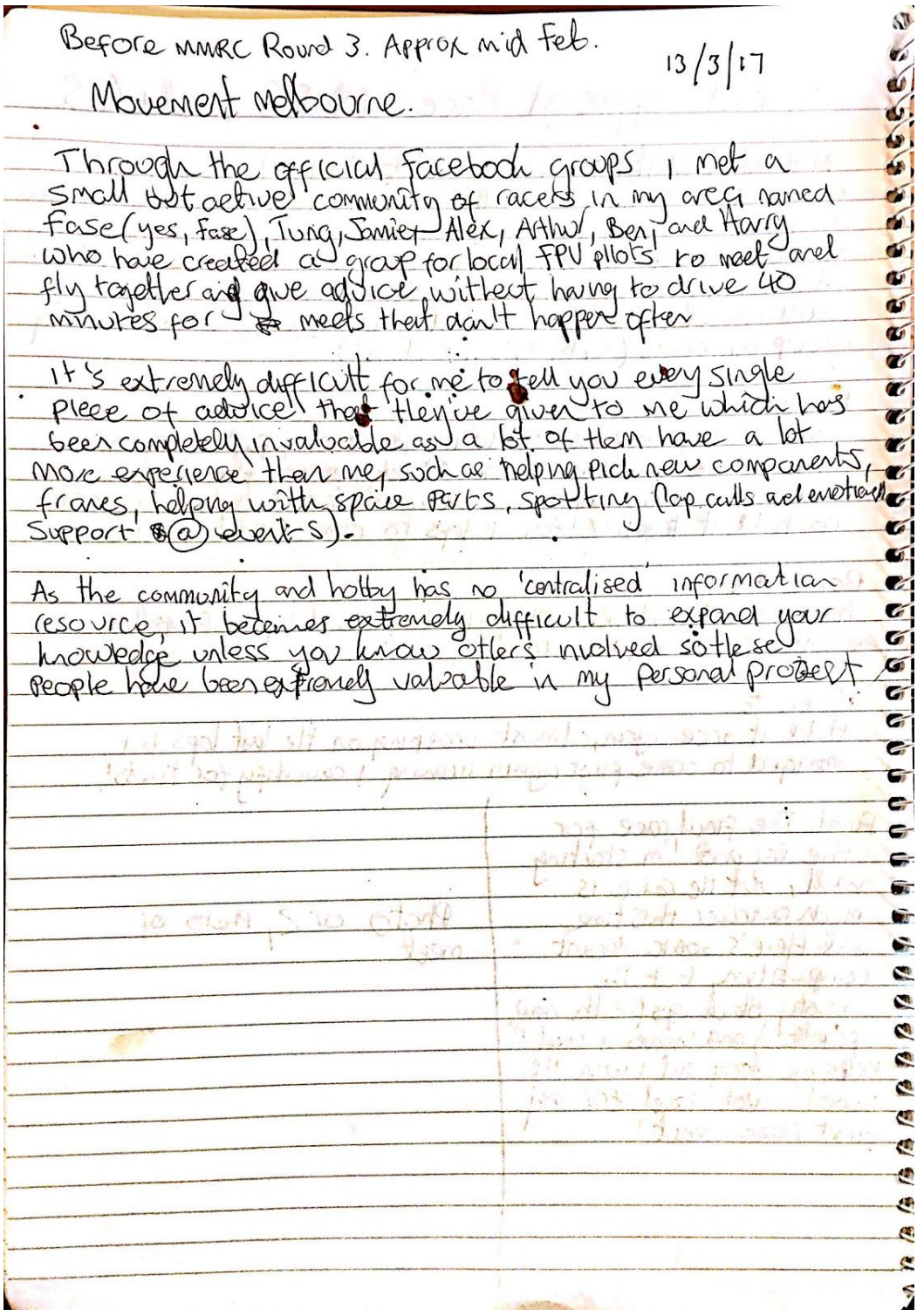
However larger quads with higher power requirements may be able to take advantage of 3S, 4S, 5s and even 6 cell batteries. The increase in cell count also brings some increased weight (depending also on battery capacity) and higher voltage. You need to check with your setup to see if it can handle the extra voltage. LiPo voltages are:

	FULL CHARGE	STORAGE	DISCHARGE (reccommended) MAX
1 cell	4.2V,	3.8V	3.3-3.2V
2 cell	8.4V x2	7.6V	
3 cell	12.6V x3	11.4V	
4 cell	16.8V x4	15.2V	14.8V
5 cell	21.0V x5		

* Discharging these LiPo cells too low may result in a battery not charging, puffing or a fire hazard.

Appendix 8 Communication skills		

Appendix 9
Social skills



Before MMRC Round 3. Approx mid Feb.

13/3/17

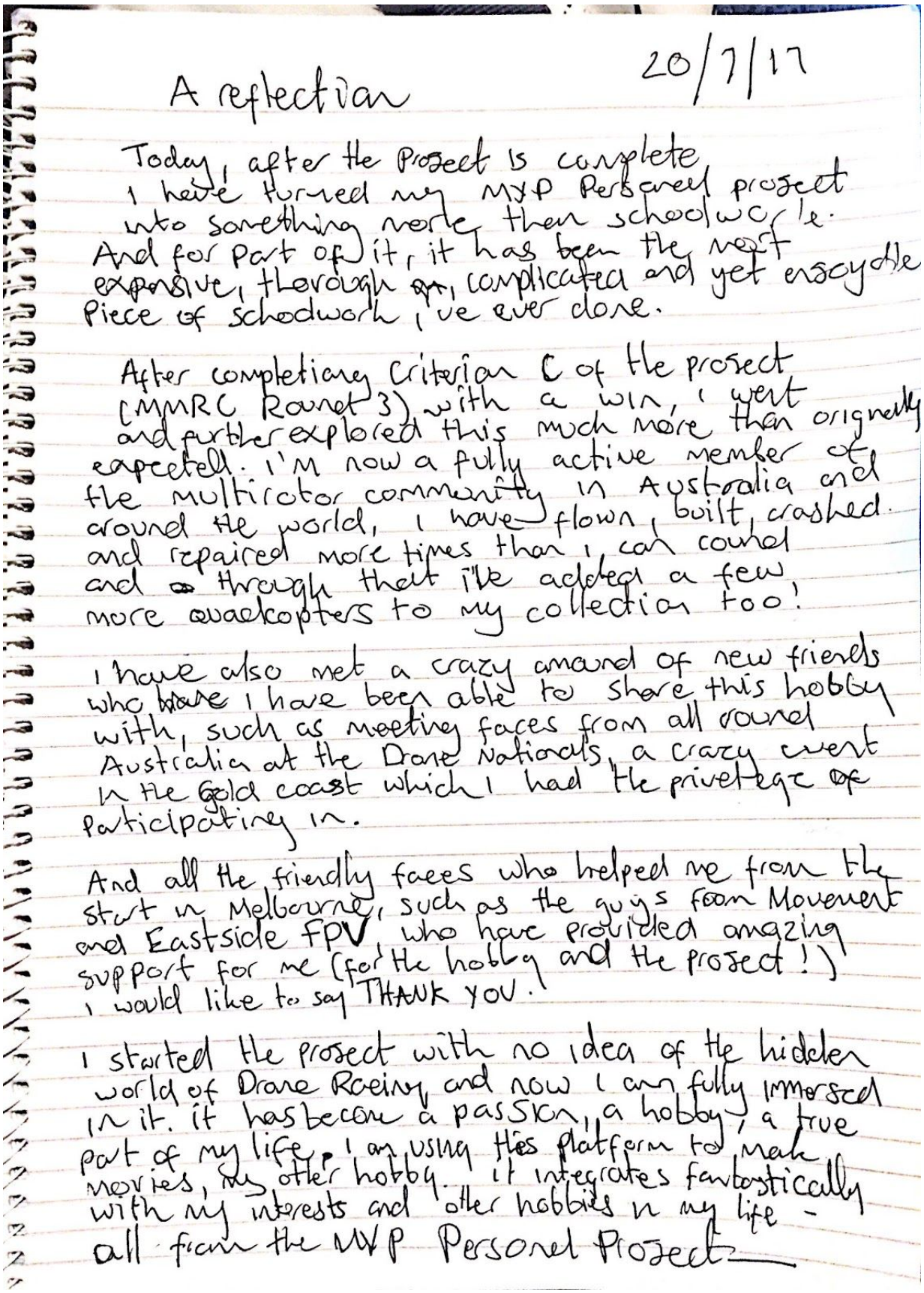
Movement Melbourne.

Through the official Facebook groups I met a small but active community of racers in my area, named Fase (yes, Fase), Tung, Smiley Alex, Arthur, Ben, and Harry who have created a group for local FPV pilots to meet and fly together and give advice without having to drive 40 minutes for meets that don't happen often.

It's extremely difficult for me to tell you every single piece of advice that they've given to me which has been completely invaluable as a lot of them have a lot more experience than me, such as helping pick new components, frames, helping with spare parts, spotting (lap calls and emotional support @ events).

As the community and hobby has no 'centralised' information resource, it becomes extremely difficult to expand your knowledge unless you know others involved so these people have been extremely valuable in my personal project.

Appendix 10
Reflection



A reflection 20/7/17

Today, after the Project is complete I have turned my MYP Personal project into something more than school work. And for part of it, it has been the most expensive, thorough, complicated and yet enjoyable piece of schoolwork I've ever done.

After completing Criterion C of the project (MYP Round 3) with a win, I went and further explored this much more than originally expected. I'm now a fully active member of the multirotor community in Australia and around the world, I have flown, built, crashed and repaired more times than I can count and through that I've added a few more quadcopters to my collection too!

I have also met a crazy amount of new friends who share I have been able to share this hobby with, such as meeting faces from all round Australia at the Drone Nationals, a crazy event in the Gold coast which I had the privelege of participating in.

And all the friendly faces who helped me from the start in Melbourne, such as the guys from Movement and Eastside FPV, who have provided amazing support for me (for the hobby and the project!) I would like to say THANK YOU.

I started the project with no idea of the hidden world of Drone Racing and now I am fully immersed in it. It has become a passion, a hobby, a true part of my life. I am using this platform to make movies, my other hobby. It integrates fantastically with my interests and other hobbies in my life - all from the MYP Personal Project.

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