1 Aims and objectives

In this section, the aim and objectives set out in the thesis will be compared to the material achievements of the project. As these were both set out in list format, they will be assessed on a per-point basis. Success of a give point is determined by whether it was met ■, unmet ■, or somewhat met ■.

Aim	Remarks
Fundamentals - minimum requirements to demonstrate the viability of the product.	
Obtain GPS location.	The tracker obtains accurate GPS coordinates, within 5m, and is capable of including information like altitude, speed, and whether the reported location is 'current'.
Transmit location to a receiver via LoRa.	Information is successfully transmitted via LoRa, however there is a small issue with occasional corruption of packets.
Continue transmission remotely for a significant period of time.	Battery life allows transmission of up to 15 hours.
Transmit at a regular interval.	The last updated location is transmitted every 5s.
Improvements - upgrades to the product to improve the user's quality of life when using the product.	
Ergonomics for owner and pet (fitting and wearing).	While a case was designed and houses the components quite well, the primary aim was protection of the electronics during testing, as opposed to suitability for this use.
Stability of the system (high uptime).	The system is capable of running unattended for long periods of time, however only the receiving end has any error handling capabilities. While it is unlikely for the transmitter to crash for any reason, this has not been stress tested in any manner.
Installable by an average person.	Setting up the antenna or other system components is not particularly difficult. The system overall could benefit from tooling (e.g. a base for the antenna) to make this viable. Furthermore, accessing the receiver software to run it requires some knowledge of Bash, which is not a fair expectation of the average person.
Location information easily viewable.	The location information is not difficult to see since it is stored plain-text in a file on the receiver. It also is not exactly easy, either, for the same reasons as above.
Production - requirements to ensure the product is suitable for manufacture.	
General safety and suitability to be worn.	This follows ergonomics, wherein the case is not designed to be worn at the stage that it is at as it cannot be attached in any way. It therefore has not been assessed for more than a superficial safety check (i.e. the battery wires will not cross over and cause a fire).
Resistance to damage and weather.	It offers no protection from the environment. However, the electronics are protected from damage and, by separation via insulating plastic, the user is protected from the electronics.
Certification requirements and law compliance.	Not considered.

Aim	Remarks
Scale considerations, especially manufacturing.	Not considered.

Table 1: Aims evaluation

Objective	Remarks
Research cat characteristics, like roaming distances and time spent outdoors.	This was well met, with the level of detail in research appropriate for defining the required specification points for the tracker.
Research LoRa radio requirements for use, and competitive products.	The exact details of the workings of LoRa radio were not delved into deeply due to limited relevance, however an overview was provided. Research into alternative products and patents was of sufficient depth to justify the relevance of the tracker.
Design the system on a macroscopic level to inform hardware and software requirements. This may include defining a specification of requirements the tracker must achieve.	A general overview was provided, including a software flowchart and hardware block diagram, so the tracker can be understood in generality. A detailed specification was also written using the aims and research as a foundation.
Develop the tracker such that it meets the outlined aims.	Some of the specification points were met, but not all of them. The aims' evaluation in table 1 provides a general overview of this, as the specification is essentially a more granular version of the aims. The tracker did meet some of the core aims, and with further work, could certainly meet outstanding points. The aims may have been too ambitious in scope given the time available, however nothing impossible was specified.
Perform tests to verify the efficacy of the tracker.	Various tests were performed to ascertain different characteristics. This included testing the lifespan and distance-transmission capabilities. The distance tests were not sufficiently thorough in order to draw solid conclusions about the tracker. This largely came down to time constraints (i.e. project development ended at this objective). The tracker would certainly have benefitted from a more thorough suite of tests on this characteristic. That is not to say the data gathered was entirely useless. With confidence, the tracker works in very poor conditions within 175m.
Develop a PCB for the tracker to minimise form-factor, and produce adequate casing for it to be fitted to a pet collar or harness. This includes verifying basic functions again, in addition to suitability for intended use on an animal.	As time ran out for test thoroughness in the previous objective, from hereon no further points were tackled. The plan was to lift the components of the tracker onto a PCB that would have minimised the size, and then develop casing around it that would be useable with a harness, however this could not be attempted due to the time available. Therefore, this point in its entirety was not engaged with.

Objective	Remarks
Gain required certifications for the product to be moved to manufacture, and design a manufacturing plan.	This objective would have defined the tracker to a point where it was potentially patentable, however was not addressed at all due to where development for the project had to end.

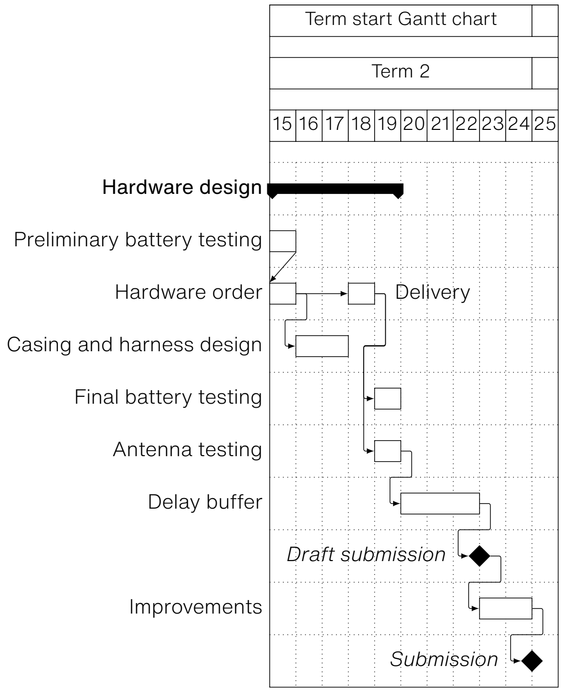
Table 2: Objectives evaluation

Taking an overview of success, the project was generally meeting the set out aims and objectives, especially so with the earlier ones. Completion of each point began to suffer as the project progressed, leading to the more ambitious goals to not be attempted. Following this project on, these unmet points would prove an excellent extension, and there is nothing to suggest they would not be achievable if given enough time.

2 Project management

Time constraints have been mentioned a number of times to this point. Project development was completed in a very short timespan, with development to produce the absolute minimum viable product completed over the space of a weekend. This may suggest rushed and therefore incomplete or buggy code, however this is not the case. The majority of the working and useable code was completed to a reasonable standard extremely quickly, and only required minor improvements from thereon. This is also the case for much of the rest of development, with many major steps taken quickly and developed to a reasonable level of polish.

The issue largely came down to hardware delivery delays. While this was somewhat expected and accounted for, the true extent was the entirety of Term 1 lost waiting for a hardware delivery. When the hardware did arrive, development progressed very quickly from thereon. For context, hardware was only available in mid-December, with develop-



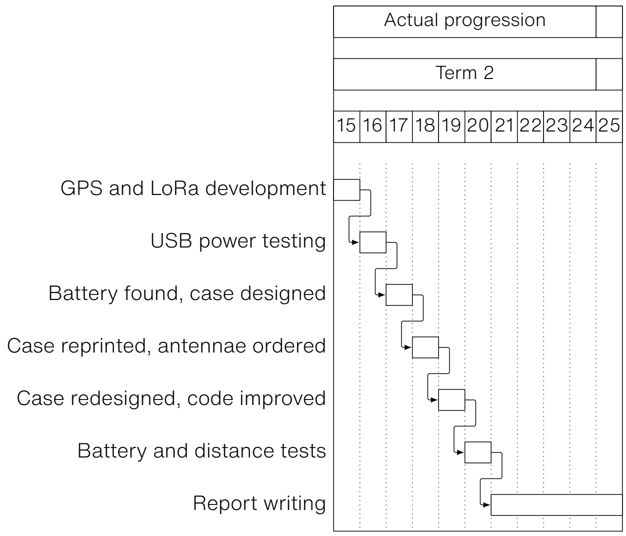


Figure 1: Gantt charts

ment starting in January. A more precise breakdown of the course of development can be found in the 'Actual progression' Gantt chart in fig. 1. As can be seen, a number of very large developmental steps were taken and refined in a very short span of time. The fact that the fundamental aims were soundly met, and subsequently verified is impressive, given the very tight timescale upon which it had to happen.

The progression followed in Term 2 would have been ideal for Term 1, thereby allowing the more ambitious and advanced objectives to be met. The plan outlined in the PFS in fact followed this general progression. This indicates that the initial plan was suitable for this project and likely would have been met, contingent on hardware having been available.

The lesson to be learnt here is that, where any particular aspect (in this case, hardware) is so pivotal to the project that progress is impossible without, ensuring mitigations are in place *beforehand* is important. For example, alternative hardware could be arranged, or development started on existing hardware, with the specific required hardware defined and ordered as early as possible. Alternative it could be sourced from elsewhere, without relying on delivery times from approved vendors only. Finally, if there is no other option than to wait for the hardware to show, the feasibility of the project overall needs to be reconsidered. A project that loses half its time simple waiting is by no means feasible.

3 Independent work

The main areas of non-independent work where advice was sought were in hardware ordering and testing setup.

In the case of hardware, after producing a shortlist and refining dependent on approved vendors and stock availability, the list was then handed off for ordering and not dealt with until the required hardware had arrived.

Test setup came in two parts. Before purchasing a battery, the expected capacity needed to be determined, the advised method of which was to purchase a current tester to measure the characteristics of the transmitter. Setting up distance testing also required use of university facilities, and arranging a location in which to install the receiver and antenna would have been difficult to do so independently.

General guidance on reprioritising particular tasks and report writing were greatly appreciated and extremely helpful to the overall completion of the project. This was particularly useful in determining tone and direction for written work.

4 Feasibility and impact

Comparing to the project feasibility study performed prior to the commencement of this project, many of the identified points hold true. The risk register identified health and safety, manufacturing issues, and delays as the most significant project risks. In the case of delays, this was referring to failing to adhere to the project plan, rather than delivery delays as referred to here. However, it ultimately means the project plan could not be followed, so the end result is much the same.

Health and safety was relevant for testing, due to the nature of electronics. Risk assessments were performed before any tests, and overall no issues occurred. Manufacturing issues also occurred, but were minimal and easily corrected for.

A major missed expectation of the PFS was live-testing of the tracker with a cat. The subject of ethical approval for this to be the case was briefly broached, however the conclusion was that far greater detail would be needed in the application, and ultimately it was not carried through in order to save time and complete more critical aspects of the project.

5 Evaluation

The three greatest learning experiences of the project are:

- Account for hardware delays such that issues with delivery cannot hold the entire project development hostage.
- Documentation writing is time-consuming and must be specifically accounted for when creating a development plan.
- Planning cannot be insular, in that other tasks not relevant to the project, but still time-consuming, must be accounted for. If they are not, the impression that the plan is poorly thought out or the project went of track may result.

The three greatest positive outcomes are:

- The project was completed to a high standard given the time available. While it is regretful that more work could not be done, it is by now means a detractor from the work accomplished.
- There was a surprising amount of programming required for this project. This was expected for the tracker, however less expected was the plotting programming requirements. In any case, the end result were appropriate and professional, while clear graphs and charts across the board.
- The greatest outcome is that the tracker does in fact work, and rather well at that. While the precise limits have not been characterised, it is suitable for tracking within most owned cats' home ranges. To make a minimum viable product, all that is needed is a waterproof casing, which is fairly simple to design.

Completed work A functioning tracker, with a small amount of refinement required to get serviceable. The system requirements were defined and used to inform hardware purchasing decisions. Once the hardware arrived, it was soldered and then programmed. Programming overall progressed smoothly, with the only issue being the occasional crash on the receiver end which was then handled safely. A case was designed and then updated using findings from the first design. Tests were designed for the tracker, and it was found to perform fairly well in these tests. Overall, a relatively successful outcome.

Future work There are some points that would be taken on in future work. More testing to completely characterise the tracker, before working to minimise the size of the transmitter. The receiver would not be too complex to modify such that it can store data in a database and serve a web frontend for the user to view live location overlaid on a map. One of the key takeaways from this project is effectively managing when things do not go to plan externally. For example, producing a backup plan of work where a critical factor (like hardware) is unavailable.