

March 31, 2022
Dr. Mike Hegedus
School of Engineering Science
Simon Fraser University
British Columbia, V5A 1S6



RE: ENSC 405W/440 Final Proposal for Highfly Technologies

Dear Dr. Hegedus,

Improving the golf playing field is the core of what the Putt From the Sky system from Highfly Technologies values. Providing accurate, and detailed green maps will allow both the professional and the amateur to succeed on the course. As such, Putt From the Sky is a golf green mapping service provided to golf courses around the world. The purpose of the attached document is to provide a formal proposal for the development of the project.

The proposal document will highlight the overview of the company and the product. This includes the risks of the project at its final phase, the benefits of putting this product on the market for commercial use, the current market competition and where Putt From the Sky differentiates. It will also outline the cost and materials used to construct the prototype, and an overview of the project planning to date and through the prototype phase.

Highfly Technologies consists of five engineering students spanning electrical, systems, and computer engineering programs. It is a hard-working and dedicated team that sets ambitious goals and strives to achieve them. The primary contact at Highfly Technologies is the Chief Communications Officer Samuel Kwon, who can be reached by email at ockwon@sfu.ca or by phone at (306)-715-9157.

Sincerely,



Ryan Stolys
Chief Executive Officer
Highfly Technologies



Highfly Technologies

Final Proposal

Putt from the Sky

ENSC 405W: Company 4
Issued on March 31st, 2022

Prepared By:

Ryan Stolys

Chief Executive Officer (CEO)

Jayden Cole

Chief Technical Officer - Software (CTO-S)

Matthew Neddoly

Chief Technical Officer - Hardware (CTO-H)

Jiyeong (Sophie) Jeong

Chief Financial Officer - Inventory Manager (CFO)

Oh Chang (Samuel) Kwon

Chief Communications Officer (CCO)



Executive Summary

Highfly Technologies goal is to help golfers reach their peak levels of performance by providing precise golf green slope maps to one slope indicator for every 5 cm² of green (the maximum permitted resolution in golf). Currently, green maps are handwritten by golfers and as a result lack significant accuracy and detail. Highfly Technologies would be entering an untapped market with only one competitor, StrackaLine, whose business model focuses directly on sales to consumers. From the market analysis, it is predicted Putt From the Sky will be able to steadily increase sales from around 750 green books in the first year to 10,000 green books by the 5th year as the library of greens books increases.

The Putt From the Sky team is made up of 5 individuals. A Software team of two, Ryan Stolys and Jayden Cole; and a Hardware Team of three, Matthew Nerdoly, Jiyeong Jeong, and Sam Kwon. Sam Kwon is the company's Chief Communications Officer and is the point of contact for the company.

The biggest risks of the Putt From the Sky project relate to the challenging hardware build required for accurate green image capturing. A backup hardware plan is in place in the event of a failure. Including setbacks, the expected delivery date for the proof of concept is April 12th, 2022, while the engineering prototype is expected August 20th, 2022. The project deliverables were chosen to fit within a budget of \$800.

List of Figures

| Figure | Caption |
|--------|---|
| 6.1 | Project Gantt Chart (Jan 10, 2022 - Aug 20, 2022) |
| 6.2 | Project Gantt Chart (Proof of Concept) |
| 6.3 | Project Gantt Chart (Prototype) |

List of Tables

| Table | Caption |
|-------|---|
| 5.1 | Business Risk analysis for Putt From the Sky |
| 6.1 | Colour Legend for Gantt Charts |
| 6.2 | Process/ Milestone Projected vs Actual Completion Dates |
| 7.1 | Cost Calculations for Putt from the Sky |

Glossary

The following table includes terms mentioned throughout the document specific to the domain and industry.

| Term | Definition |
|------|-------------------------|
| DEM | Digital Elevation Model |

Contents

| | |
|--|-----------|
| Executive Summary | 4 |
| List of Figures | 5 |
| List of Tables | 5 |
| Glossary | 5 |
| 1 Introduction & Background | 7 |
| 2 Company Details | 8 |
| 3 Project Scope Statement | 10 |
| 4 Market Analysis | 11 |
| 5 Risks and Benefits | 12 |
| 6 Project Planning | 15 |
| 7 Project Cost | 19 |
| 8 Conclusion | 20 |
| 9 References | 21 |

1 Introduction & Background

In athletics professional and amateur athletes are always looking for an edge to perform at the highest level possible. To attain this edge, technology is used in a variety of ways to improve consistency and performance. In some cases research and technology is applied to create superior equipment that can push physical feats to the absolute max. Another opportunity to apply technology is to attain knowledge about yourself, an opponent, or the game itself. Technology can be used to gain a new perspective and find advantages that a human might not recognize.

Over the last 20 years, the golf world has seen a substantial increase in the use of technology to help improve performance at the top level of the game. Highfly Technologies intends to add to this expansion by addressing an area of golf that still relies on unreliable and inaccurate practices. This particular area is the yardage book used by amateurs and professionals alike. Yardage books are a set of notes and maps for each of the 18 holes of a golf course that contains information such as distance to specific hazards, reminders for the player, and maps of the green. Except for the professionals playing at the highest level, the green maps in yardage books are handwritten maps that usually lack detail and are not to proper scale. Despite competitor StrackaLine® providing some services related to green mapping, their methods are not widespread. As such, green maps are a relatively untapped market in the technological expansion in golf.

To do this, Highfly Technologies is proposing the Putt from the Sky project. It will use Digital Elevation Models (DEMs), first introduced near the end of the 1900s. Over the past 40 years, DEM quality and application in computer vision projects has improved. Current DEMs have reached sufficient quality to be applicable to model water flow, render 3D visualizations, satellite navigation, surface analysis, and many others [1]. Although there are many ways to acquire the data for a DEM, photogrammetry currently stands out because of its ability to make a high-resolution model from a set of images. Highfly Technologies is determined to add golf green mapping as a DEM application using photogrammetry.

The Highfly Technologies team has been working with various methods to acquire and use photogrammetric data to create accurate DEM's. Once the product is complete it will swiftly gather data from a golf course, efficiently process that information and model the course with precision. The models created will be used to present an easily comprehensible perspective of the golf greens that can be used in the decision making process for golfers. Amateurs and pros alike will benefit as the system can be applied at any desired golf course. The Highfly Technologies team is eager and excited to bring a product to the market that will improve the performance level of all golfers.

2 Company Details

Company Name: Highfly Technologies



Project Name: Putt from the Sky



Highfly Technologies is a technology company focused in developing innovative topographic mapping solutions for unique applications. The team at Highfly Technologies consists of a mix of electronics, computer and systems engineering students from Simon Fraser University and have years of both academic and industry experience. Below we have outlined the team members, their skills, expertise, and their role in the Putt from the Sky project.

Ryan Stolys - Chief Executive Officer (CEO)

As a 5th year Computer Engineering student, Ryan Stolys had an opportunity to work for four months at OSI as a software engineer and eight months at Mojio Inc. as a platform engineer. He is a founder of One Iota Performance Inc, a Golf performance enhancing software. Ryan has experience with cloud based applications, object oriented programming, microservices architecture development, NoSql and SQL database design, maintenance and development, and software project management. Ryan will help the software team to build the software infrastructure and 3-D mapping. He is also leading the company to deliver a successful product and brings the experience of a lifelong competitive golfer.

Jayden Cole - Chief Technical Officer - Software (CTO)

Being in the 5th year of his Computer Engineering degree, Jayden has had an opportunity to work for eight months at Schneider Electric as a firmware developer and for eight months at SFU's Biomedical Optics Research Group as an AI machine learning, image processing, and signal processing engineer. During his experiences, he took part in the software side of AI machine learning, image processing and built leadership skills to guide teammates on tasks. Jayden will lead the software team to design the software infrastructure of the design.

Matthew Neddoly - Chief Technical Officer - Hardware (CTO)

As a 5th year Systems Engineering student, Matthew Neddoly had an opportunity to work at Canadian Circuits Inc. as a Quality Assurance Technician and at Webb Electronics as a Hardware Engineer. He has been involved in soldering, 3-D CAD, and PCB designs. Matthew was the bridge between the software and hardware team at his previous companies, and will continue to do so at Highfly Technologies. He maintains flexible schedules throughout the timeline to ensure deadlines are met. Since he also has firmware experience, he helps the hardware team to integrate the flight controller system and build the successful drone.

Jiyeong Jeong - Chief Financial Officer (CFO)

Jiyeong Jeong had an opportunity to work for eight months at St. John's school as an IT Specialist and one year at Tantalus Systems Inc. as a hardware test engineer. During her experiences, she took part in both hardware and software teams from fixing various software bugs to hardware components. Also, she took part in designing PCBs as well as performing reliability tests. Based on her experience, she is helping the hardware team to purchase parts, solder components and build the drone while completing her 4th year of an Electronic Engineering degree..

Sam Kwon - Chief Communication Officer (CCO)

4th year SFU Electronics Engineering student, Sam Kwon, has had an opportunity to work at OSI Maritime Systems Ltd. as an electrical engineer and at Enersys as a test engineer. During his experiences, he perfected his soldering abilities, cable management and cable designs. He has experience in formal technical documentation on electrical and system designs. He is the main point of contact for the Putt From the Sky project and will help the hardware team on building the drone.

3 Project Scope Statement

Project Name: Putt From the Sky
Completed By: Highfly Technologies

Project Start: 10 Jan, 2022
Project End: 19 Aug, 2022

Project Purpose:

Generate accurate golf green surface maps for players.

Description:

Highfly Technologies will create a comprehensive and semi-automatic pipeline to process golf green surfaces as a service to golf courses; maps from this service are sold to golfers.

Desired Results:

Produce to scale green maps with one slope point per 5 cm²

Exclusions:

Hazards close to green edges may appear on green maps, but will not be drawn with slope indicators.

Communication Needs:

- Highfly Technologies will discuss project progress weekly as a company.
- The Hardware and Software teams will meet separately once a week.
- Stakeholder meetings will occur, at minimum, biweekly.
- Communication through company Discord for all messaging.
- Email messaging will be used for outside stakeholders.

Acceptance Criteria:

Achieve desired results (above) on a full 18 hole golf course

Constraints

1. Budget for the project is \$700
2. Team members: Ryan Stolys, Jayden Cole, Matthew Nездoly, Sam Kwon, Jiyeong Jeong

4 Market Analysis

Today green maps in yardage books are often handwritten maps that lack detail and accuracy. Competitor StrackaLine provides services related to green mapping however, their products are not widely adopted. StrackaLine's business model targets golfers directly for their green book sales. Highfly Technologies believes more success can be achieved through targeting golf courses directly in addition to consumers in order to engage with a wider proportion of the total addressable market. Golf is played by more than 60 million people across 160 countries, of which approximately 85%, or 51 million people, play golf at a golf course [2]. Of this group about 20% are expected to be looking for opportunities to improve their performance. This portion of the market, 10.2 million golfers, make up Highfly Technologies serviceable available market. With limited competition this provides Highfly Technologies with high growth potential for its green mapping solution. When Highfly Technologies launches it will need to build up its library of available green books for consumers to purchase. Given this limitation it is predicted Putt From the Sky will be able to steadily increase sales from around 750 green books in the first year to 10,000 green books by the 5th year.

Highfly Technologies main competitor in the green book market is StrackaLine. StrackaLine provides multiple versions of their green and course books which include a combination of the full course detail and green details. StrackaLine is moderately well-known amongst high-level amateur golfers but is not widely adopted and does not provide the value necessary in their direct to consumer sales to significantly disrupt the common practices in green mapping. Highfly Technologies aims to make a more significant disruption by marketing the product directly to golf courses rather than consumers directly. All golf is played at golf courses and this is where Highfly Technologies Putt from the Sky solution demonstrates its value. This market strategy will help to reduce friction in reaching consumers and help to improve the brand recognition of Highfly Technologies with the common golfer. The Putt from the Sky solution currently aims to develop detailed green maps; however expanding the project scope to mapping the entire golf course is in consideration following the success of the engineering prototype for the greens book. StrackaLine currently provides this full course mapping capability and experts have found StrackaLine to be useful in the fairway as well as the putting green [3]. It is expected this will be a natural evolution of the Putt from the Sky project to maintain competitiveness with StrackaLine's offerings.

Furthermore, Highfly Technologies recognizes the technology developed from the Putt from the Sky project has many applications outside of golf such as surveying and general terrain mapping. While applying the technologies to domains outside of golf greens falls outside the scope of the current project it is a domain Highfly Technologies will explore as the project matures.

5 Risks and Benefits

Highfly Technologies has thoroughly analyzed the risks and benefits for both the business and society. Table 5.1 presents the business risks associated with the Putt From the Sky product. It lists the identified risks, the respective risk score, and who and how the team will accept, mitigate, or eliminate this risk. The Highfly Technology team focuses on risks according to the projected risk score. Each risk is given a score from 1-5 based on its projected impact to the project (one being low impact, five being detrimental to project success), as well a score from 1-5 for the probability of the risk occurring. The risk score is calculated by multiplying the impact score and probability scores. Highfly Technologies then classifies risks into three groups, low priority risks (Risk score 0-5), medium priority (risk score 6-11), and high priority risks (12+). High priority risks will be given the most attention throughout project development as they are critical to project success and very likely to occur.

| Risk | Risk Score (Impact x Probability) | Strategy | Who |
|---|--------------------------------------|--|-----------------------|
| Access to some courses not permitted | $4 \times 2 = 8$ | Mitigate by using communication and persuasion skills to promote benefits | CEO/CCO |
| Golf courses in drone restricted areas | $5 \times 1 = 5$ | Accept the risk that not all golf courses will be located in drone accepted areas | CEO |
| Hardware components arrive late | $3 \times 2 = 6$ | Mitigate by ordering parts early - spend on faster shipping if necessary | CFO |
| Hardware components fail or are faulty | $5 \times 4 = 15$ | Accept that new parts will need to be created/ordered if this happens | CFO, CTO-H |
| Hardware component breaks in use | $5 \times 4 = 20$ | Mitigate by using safe hardware operating procedures | CTO-H, CCO, CFO |
| Sensors are of insufficient quality | $5 \times 3 = 15$ | Eliminate by acquiring accurate sensors | CTO-H, CFO |
| Software depends on outside faulty code modules | $4 \times 2 = 8$ | Eliminate by ensuring module works in pipeline, then do not allow for the code to be updated in the project | CTO-S, CEO |

| | | | |
|--------------------------------------|----------|--|------------|
| Software OOM issues, slow renderings | 3x3 = 9 | Mitigate using efficient data collection paths and efficient processing algorithms | CTO-S, CEO |
| Software bugs | 3x4 = 12 | Mitigate using excellent software practices (code standards, iterative development) | CTO-S, CEO |
| Insufficient budget | 4x4 = 16 | Mitigate by extensively researching cost effective options for project purchases | CFO |

Table 5.1: Business Risk analysis for Putt From the Sky

Despite the numerous risks Highfly Technologies would undertake for the development of the Putt From the Sky service, there are numerous benefits to the business that require careful consideration. Listed below are some of the identified business benefits to Highfly Technologies from the successful execution of the project:

Market Share

- Only one direct competitor, StrackaLine
- Blue Ocean market

Brand Identity

- As Putt From the Sky is Highfly Technologies' first product, the successful execution of this service will cement Highfly Technologies as a leader in topographic mapping

Customer Experience

- This is the first customer facing product for Highfly Technologies, it is a great opportunity to develop an excellent customer experience

Brand Exposure

- Putt From the Sky exposes Highfly Technologies for the first time into the Topographic mapping market

Highfly Technologies has also identified the risks and benefits to society. These are listed below:

Society Risks

- Drones are dangerous when not operated safely, however, a trained employee will be monitoring the observation area for hazards. This is a high project impact, but low likelihood event, therefore has a risk score of $5 \times 1 = 5$
- At the end of the product life cycle, plastic and electronics are not easily recyclable. Since there is only one drone, it is given a risk score of low impact against project success, high likelihood of occurring $1 \times 5 = 5$

Society Benefits

- Allows amateur golfers to play with the same terrain information as the professionals
- Encourages golf and outdoor activities as a fun option for a healthy lifestyle

6 Project Planning

Highfly Technologies values team communication and timelines. To keep the team on track and in-sync, the team uses Jira Project Tracking from Atlassian. This system provides the team with a clear roadmap for the various processes and milestones throughout the project. The overall project Gantt chart is shown in Figure 6.1. The various colours on the chart indicate different types of processes and milestones, these are described in Table 6.1.

| Colour | Green | Blue | Red | Gray |
|---------|--------------------------------------|----------|----------|-------------|
| Meaning | Project Document / Course Submission | Hardware | Software | Integration |

Table 6.1 - Colour Legend for Gantt Charts

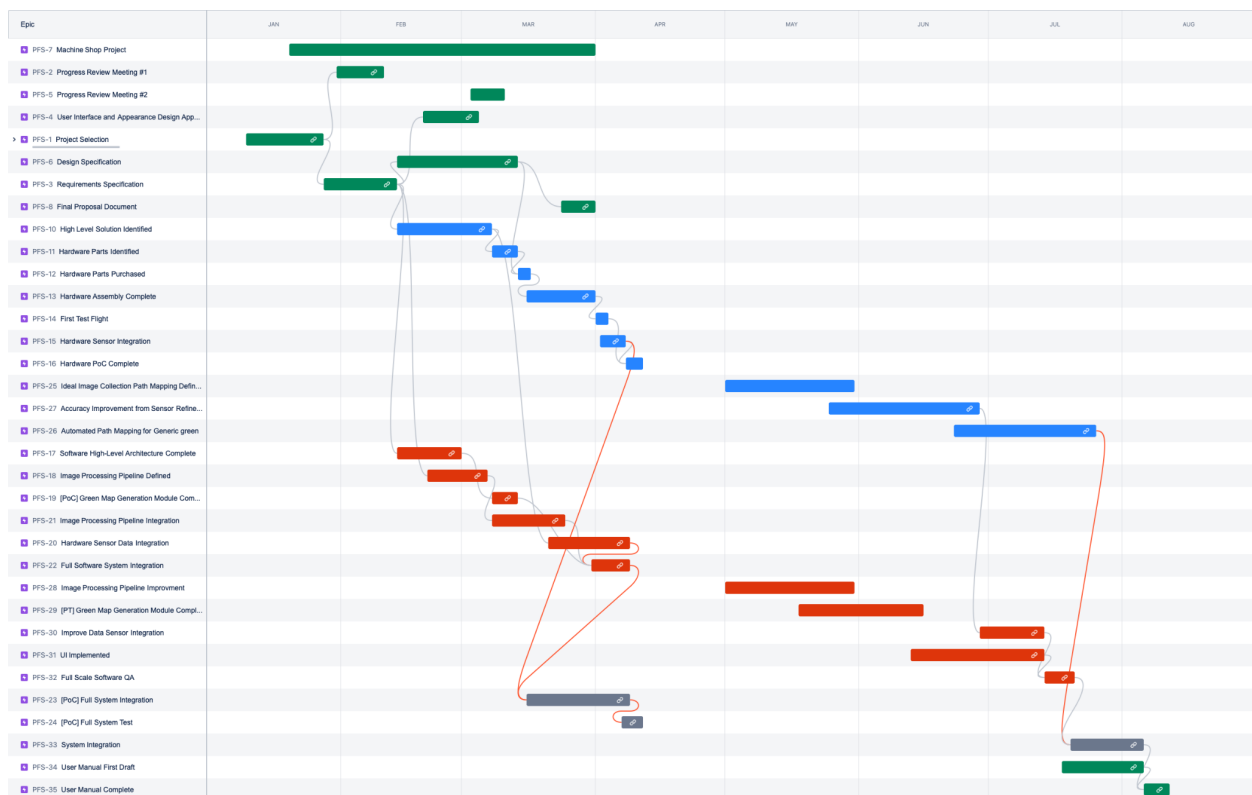


Figure 6.1 - Project Gantt Chart (Jan 10, 2022 - Aug 20, 2022)

Below the Gantt chart has been broken down into the two core components of the project. Figure 6.2 shows the Gantt chart for the Proof of Concept and Figure 6.3 shows the Gantt chart for the Prototype. These sub charts provide a more detailed look at specific portions of the project.

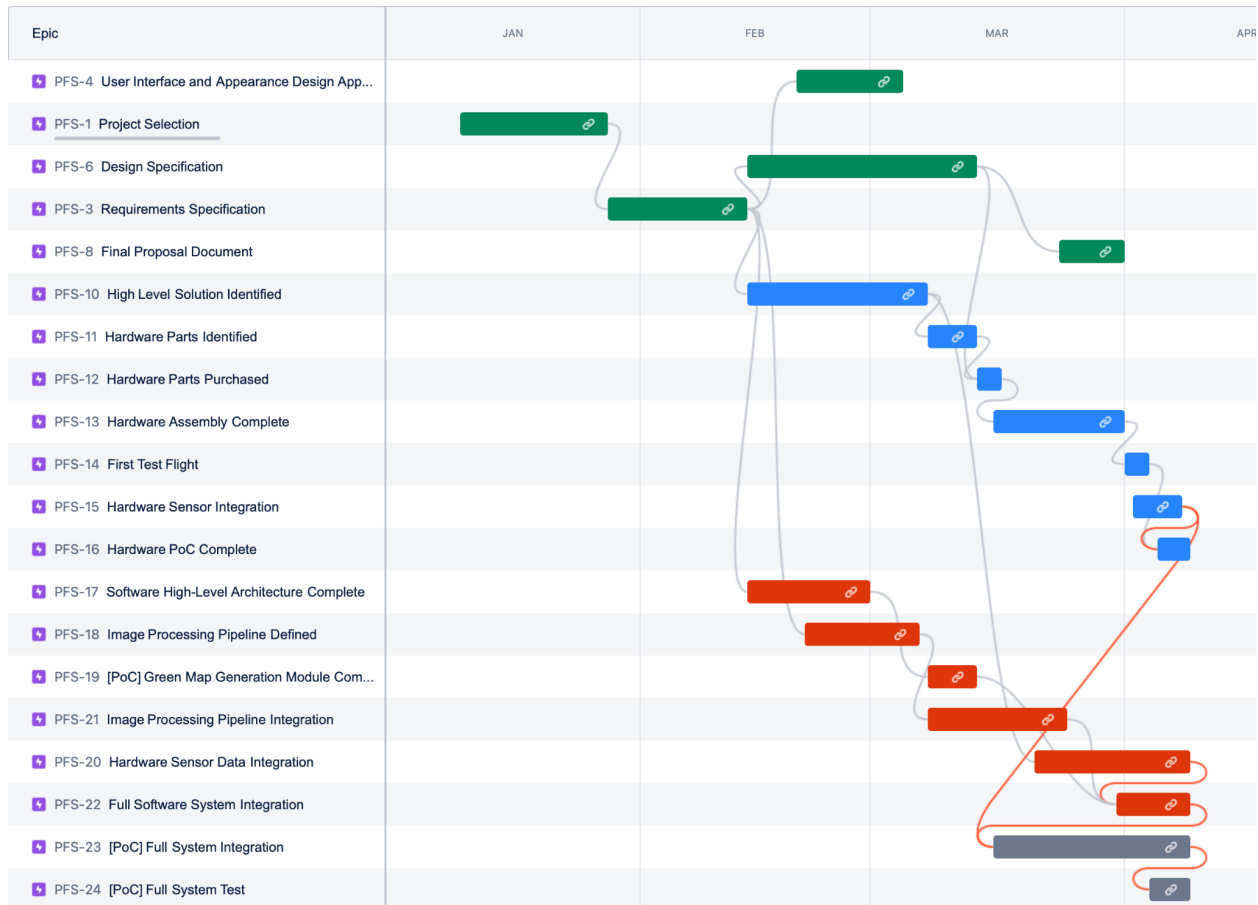


Figure 6.2 - Project Gantt Chart (Proof of Concept)

Figure 6.2 shows all the processes and milestones predicted dates. Table 6.2 shows each of the processes and milestones listed in Figure 6.2 and their actual completion dates compared to the predicted dates.

| Process / Milestone | Predicated Completion Date | Actual Completion Date |
|----------------------------|----------------------------|------------------------|
| Project Selection | January 27th, 2022 | February 3rd, 2022 |
| Requirements Specification | February 13th, 2022 | February 13th, 2022 |

| | | |
|--|---------------------|--|
| User Interface and Appearance Design | March 4th, 2022 | March 4th, 2022 |
| High-Level Software Architecture Defined | February 28th, 2022 | February 20th, 2022 |
| Image Processing Pipeline Defined | March 6th, 2022 | March 12th, 2022 |
| High-Level Hardware Solution Identified | March 7th, 2022 | March 3rd, 2022 |
| [PoC] Green Map Generation Module | March 13th, 2022 | February 25th, 2022 |
| Hardware Parts Identified | March 13th, 2022 | March 3rd, 2022 |
| Design Specification | March 13th, 2022 | March 13th, 2022 |
| Hardware Parts Purchased | March 16th, 2022 | March 5th, 2022 |
| Image Processing Pipeline Integration | March 24th, 2022 | March 26th, 2022 |
| Hardware Assembly Complete | March 31st, 2022 | In Progress - Projected April 3rd, 2022 |
| First Test Flight | April 3rd, 2022 | In Progress - On Schedule |
| Hardware Sensor Integration | April 7th, 2022 | In Progress - Ahead of Schedule |
| Full Software System Integration | April 8th, 2022 | In Progress - On Schedule |
| Hardware Sensor Integration | April 8th, 2022 | In Progress - Ahead of Schedule |
| Full System Integration | April 8th, 2022 | In Progress - On Schedule |
| Hardware PoC Complete | April 8th, 2022 | In Progress - On Schedule |
| Full System Test | April 8th, 2022 | In Progress - On Schedule |

Table 6.2 - Process/ Milestone Projected vs Actual Completion Dates

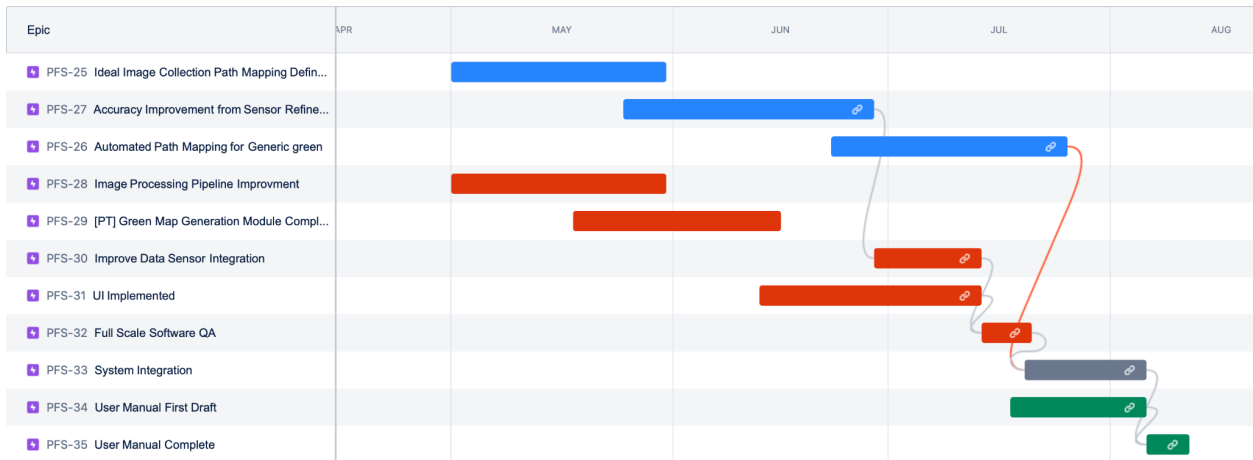


Figure 6.3 - Project Gantt Chart (Prototype)

7 Project Cost

An estimated cost for the components required to build the prototype is given in the table below. All the components below are required to build the drone. The drone flight controller was chosen to be Navio2. A 10% contingency fund is added to the cost calculation as a safety measure.

| Components | No. of Quantity | Cost per quantity (\$) | Total Cost(\$) |
|--|-------------------------|------------------------|----------------|
| Frame | 1 | 70.50 | 70.50 |
| Battery | 1 | 55.99 | 55.99 |
| Motors | 4 | 38.06 | 152.24 |
| Raspberry Pi | 1 | 90 | 90 |
| Navio2 | 1 | 284.97 | 284.97 |
| ESC bundle | 1 | 44.79 | 44.79 |
| Propellers | 4 | 5.64 | 22.56 |
| Power Module and cables | 1 | 9.29 | 9.29 |
| Contingency | 10% of Grand Total Cost | | 73.034 |
| Grand Total Cost | | | 730.34 |
| Grand Total Cost with Contingency | | | 803.374 |

Table 7.1 - Cost Calculations for Putt from the Sky

Funding is crucial for the progress of the project. Various funding sources are available to Highly Technologies such as the Engineering Science Student Endowment Fund (ESSEF) and Wighton Engineering Development Fund.

1. The Engineering Science Student Endowment Fund (ESSEF) is provided by the Engineering Science Student Society (ESSS). Putt From the Sky falls under Category B - Entrepreneurial, since the product has plans to advance it to adapt for commercial use.
2. The Wighton Engineering Development Fund is managed by Dr. Andrew Rawicz and helps fund projects that benefit society. The description of this project aims to help society by creating a performance tool that will benefit golfers.

If the above sources are unavailable, each member of the team will contribute the remaining costs to successfully deliver the product.

8 Conclusion

Putt from the Sky is a product that has the potential to make a significant impact on the game of golf for the common consumer. The product will safely and reliably create greens maps for any golf course. Golfers using this product will be thrilled to finally have access to the same information those at the highest level have and will certainly be able to utilize the information to improve their on-course performance. While StrackaLine provides direct competition to Highfly Technologies there is still plenty of room for growth in the market. The Highfly Technologies team will deliver this product on time and on budget in-order to create satisfied customers and business partners. While many risks exist, as outlined in [section 5](#), the team's awareness and mitigation strategies for each identified risk will increase the probability of success. Despite the risks involved with this product the benefits are clear. Highfly Technologies is driven by the mission of providing innovative topographic solutions for unique applications and will continue to do so beyond the Putt from the Sky solution.

9 References

- [1] E. Peterson, M. Klein, R. Stewart. Whitepaper on Structure from Motion (SfM) Photogrammetry: Constructing Three Dimensional Models from Photography. (2015) pp 2.
- [2] *Global Golf Equipment Market Size Report, 2019-2025*. [Online]. Available: <https://www.grandviewresearch.com/industry-analysis/golf-equipment-market>. [Accessed: 30-Mar-2022].
- [3] Amateurgolf.com, “Strackaline Greens Guide: AG Equipment Panelist Review,” *AmateurGolf.com*, 03-May-2021. [Online]. Available: <https://www.amateurgolf.com/golf-tournament-news/27759/StrackaLine-Greens-Guide--AG-equipment-panelist-review>. [Accessed: 30-Mar-2022].