



Integrated Fire-Control Optic and Ballistic Solution

Project Proposal for ENSC 405W

Company 15
July 30, 2023

Name	Email Contact	Roles/Affiliations
Braden Choy	bchoy@sfu.ca	Chief Executive and Communications Officer
Bowie Gian	bgian@sfu.ca	Chief Technology Officer
Mint Luc	minh_luc@sfu.ca	Chief Marketing Officer
Swapnil Patel	svpatel@sfu.ca	Chief Financial Officer
Hong Shi	hxshi@sfu.ca	Chief Operations Officer

July 30, 2023

Dr. Michael Hegedus

School of Engineering
Simon Fraser University
8888 University Drive
British Columbia, V5A 1S6

Re: ENSC 405W Integrated Fire-Control Optic and Ballistic Solution Project Proposal

Dear Dr. Hegedus,

This project proposal documentation for the Integrated Fire Control Optic and Ballistic Solution was prepared by AeroTrack Research Inc. in partial fulfillment of requirements for ENSC 405W: Project Design, Management, and Documentation (Capstone A).

This project was inspired out of a need for soldiers to effectively engage targets at unknown ranges with a greater degree of accuracy compared to existing rifle optic solutions. In addition, shooting from unconventional positions changes the trajectory of the projectile relative to the rifle optic and currently requires the soldier to mentally compute their point of aim at certain distances. Integrating a ballistic solution and fire control into the rifle optic itself reduces the amount of information a soldier must process to provide effective fire on target.

AeroTrack Research Inc. consists of 5 SFU Engineering students: Braden Choy, Bowie Gian, Mint Luc, Swapnil Patel, and Hong Shi. Each team member provides their own unique set of perspectives, experiences, and specializations to this project.

Thank you for taking the time to review our project proposal documentation for the Integrated Fire Control Optic and Ballistic Solution. If there are any questions or concerns with our product, please contact the Chief Executive and Communications Officer Braden Choy at bchoy@sfu.ca.

Sincerely,

A handwritten signature in black ink, appearing to read "Braden Choy", written in a cursive style.

Braden Choy
Chief Executive and Communications Officer
AeroTrack Research Inc., Company 15

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Glossary

Cant:

Cant refers to the angular rotation of a rifle in the plane perpendicular of the direction to the target and where the barrel is pointed.

Elevation:

Elevation refers to the initial height of a rifle with respect to the target. A rifle held by a shooter from an elevated position aimed at a target below will have a negative angle of elevation, and a target above the shooter will have a positive angle of elevation.

OLED (Organic Light Emitting Diode):

OLED is an advanced display technology used in devices like smartphones and TVs. It uses organic compounds to emit light when electricity passes through them, eliminating the need for a backlight. OLED screens offer vibrant colors, high contrast, and fast response times.

IFOBS (Integrated Fire-Control Optic and Ballistic Solution):

IFOBS is an advanced system used in military applications to enhance firearm accuracy. It combines optics, sensors, and ballistic computation algorithms to provide real-time targeting information, improving precision over long distances.

NGSW (Next Generation Squad Weapon):

NGSW refers to the Next Generation Squad Weapon, a state-of-the-art family of small arms being developed to replace the current M4 carbine and M249 Squad Automatic Weapon (SAW) in the United States Army. These advanced weapons offer improved accuracy, lethality, and versatility to enhance infantry squad capabilities on the modern battlefield.

CAGR (Compound Annual Growth Rate):

CAGR is a financial metric that calculates the average annual growth rate of an investment or business over multiple years, factoring in the effects of compounding. It is commonly used for comparing investments and evaluating business performance.

XM157:

The United States Army's XM157 is a optical sighting optic and system which is mounted on the XM7 rifle as part of the Next-Generation Squad Weapon (NGSW) Program.

1 Introduction

The use of rifle scopes greatly enhances accuracy and marksmanship of a shooter and is a crucial component of military training. When discussing army training, accuracy and efficacy are crucial. AeroTrack Research Inc. is proud to introduce a cutting-edge ballistics tracking system designed to revolutionize the shooting experience. Our main goal is to create a sophisticated device that shows precise aiming and bullet drop points to a shooter.

At AeroTrack, we value simplicity and efficiency. To accurately calculate the bullet drop point, our innovative system uses projectile motion principles combined with environmental factors. We can reliably determine the distance, elevation, and cant angle by incorporating a laser rangefinder and accelerometer into the design, providing shooters with real-time, data-driven insights for precise targeting. We will provide a detailed overview of the system in this proposal document. We are committed to delivering a dependable, user-friendly, and cost-effective solution that sets a new standard in the shooting industry as AeroTrack Research Inc.'s first product.

2 Project Overview

2.1 Background

Our initial focus was automating the calculation of the bullet drop point for shooting applications, an essential aspect of precision shooting. We aimed to create a system that would accurately determine the bullet's trajectory based on projectile motion with air resistance, providing shooters with real-time information on where the bullet would hit in relation to the intended target. However, as we delved into the project, we realized that the scope was somewhat narrow, as achieving the required bullet drop precision demanded a more comprehensive approach.

In response to this realization, we decided to expand our objectives and build a dedicated testbed. This testbed would serve as a platform to meticulously test and fine-tune the bullet drop precision in real-life scenarios. By integrating the testbed with a feedback function, users will be able to receive precise aiming point information and observe how the testbed accurately moves the gun to the prior aiming position. This comprehensive approach will allow us to ensure AeroTrack delivers a product that not only calculates the bullet drop point with utmost precision but also provides a seamless user experience, catering to shooting enthusiasts' needs.

2.2 Scope

In this document, we will justify the project made by AeroTrack during the development of their advanced rifle scope.. This project aims to create a cutting-edge device that precisely calculates the bullet drop point for shooting applications, enhancing shooters' accuracy and performance. The project will thoroughly enumerate and justify the design choices made during the development of the rifle scope. It will include a comprehensive system overview and an in-depth examination of the Integrated Fire Control System (IFOBS) of the rifle optic and its associated testbed.

Additionally, the project will explore alternative design options and develop a comprehensive test plan that was considered throughout the development process. The objective is to achieve a rifle scope that meets the highest standards of accuracy and functionality.

3 Project Justification

This section analyzes the risks and benefits of both the IFOBS and testbed.

3.1 Risk

The IFOBS is a low voltage electronic device with no moving parts. There are negligible safety hazards to the user. All electronic parts will be enclosed in a durable, waterproof housing to minimize the risk of electric shock and damage to the components. The rangefinder implements a Class 1 (EN/IEC 60825-1) eye-safe laser which is safe for use in all normal use conditions [1][2].

The testbed is designed to hold a firearm securely and aim at a location input by the user. This device is intended for testing optics and firearms only. To prevent the firearm from aiming at an unsafe location, restrictions have been implemented both physically and in the software. These will limit the firearm to about 10 degrees of movement in vertical and horizontal directions. The user will be responsible for ensuring the testbed is clear of any obstructions and the area to the target is clear before mounting the firearm. Another safety design choice is to not include an automatic trigger pull. This requires the user to double check everything is safe and ready before firing. Mounting the firearm is completed by securing the handguard and stock with clamps. Additional weight may be added to the testbed to reduce its movement from firing. This greatly reduces the chance the firearm can point at an unsafe location from recoil.

As the product is designed around firearms, potential anti-gun legislation can be a significant hindering factor in the market. IFOBS addresses the accuracy needs of long-range projectile systems and the company could be stifled by political motivations. AeroTrack Research believes that it is the end-user who must ultimately decide how IFOBS will be used.

3.2 Benefits

As discussed above, the IFOBS has low risks, therefore the benefits brought will greatly offset the risks. Our product projects the calculated point of impact in real-time. By pointing the optic at targets at different ranges, the user can quickly build an intuition on how distance affects the projectile's ballistic solution. The IFOBS can help users focus on training their form and technique, by removing the need for trajectory compensation. This also increases the chance of hitting the target during stressful situations, when there is limited time to mentally calculate the point of impact. In future versions, we may consider providing the accelerometer data for technique assessment. This is valuable data because it can clearly show if the user is anticipating recoil too early or if their trigger pull is affecting their aim, for example.

Displaying the calculated point of impact on the optic is a new technology that does not have much research. An optic that displays dynamic information is currently very rare, meaning there is limited competition in this area of optics.

The testbed can aim the firearm very precisely. This allows users to test the accuracy of firearms and optics consistently, reducing the chance of human error from aiming. It can also be used to zero optics or validate an optic's ranging marks. The testbed also reduces the testing time because users need to spend less time readjusting the aim of the firearm. Further development may include recoil impulse measurements or an option to readjust the aim after recoil which will increase the efficiency of rifle and optic testing.

4 Market Analysis

Most commonly used are shooter-spotter pairs where the spotter measures the distance and wind speeds to the target. The shooter calculates the optic adjustments and fires the shot while maintaining good shooting fundamentals. With the rise of digital optic systems, camera scopes with an onboard computer and screen with customizable displays and accessories [3]. Laser rangefinders have been integrated into the digital sight with a simple bullet drop reticle displayed to compensate for distance. Recently, the US Army's XM157 [4] contains a laser rangefinder and ballistics calculator which displays target point of aim, and it integrates onto a conventional analog rifle scope. As the NGSW program is still in its experimental phase, little is known publicly of its capabilities.

4.1 Military and Law Enforcement

IFOBS is mainly marketed towards military and law enforcement training where their forces would benefit from effective education on their weapon systems. In 2023, the Canadian Military and Department of National Defence were given a budget of \$36.7 billion, or 1.29% of the country's GDP [5]. As Canada is currently failing to meet NATO military spending commitments of 2.00% of GDP, the budget can expect to grow if Canada meets its spending goal. However, due to a broken procurement process and low enlistment numbers, the Canadian Military may not wish to adopt new technology, even at lower prices.

Next, we can analyze international militaries and law enforcement agencies, mainly in the United States. Among NATO nations, few are meeting a 2.00% GDP commitment so their budgets may increase to satisfy their requirement. An example would be the US Army's 2020 contract for 120,000 Direct View Optics (DVO) which totals around \$77.2 million [6]. Unfortunately, the cost of rifle optics are usually not easily accessible as military contracts typically include the cost of the rifle, optic, and accessories together in the budget, if at all.

4.2 Civilian Market Canada

AeroTrack's IFOBS can serve as a valuable teaching aid for firearms instructors and marksmanship educators. By incorporating this advanced technology into training sessions, instructors can provide students with real-time feedback on their shooting performance. The optic's precise ballistics calculations and testbed adjustments students to visualize and understand the complexities of long-range shooting in a highly practical manner. Learners can grasp key concepts more effectively, improve their accuracy, and develop a deeper appreciation for the science behind shooting.

We can use the following statistics on firearms ownership in Canada to estimate our total available civilian market. However, expanding into international markets such as the United States of America where firearms ownership is normalized among the population, would provide a significantly larger target market and will be explored in the next section.

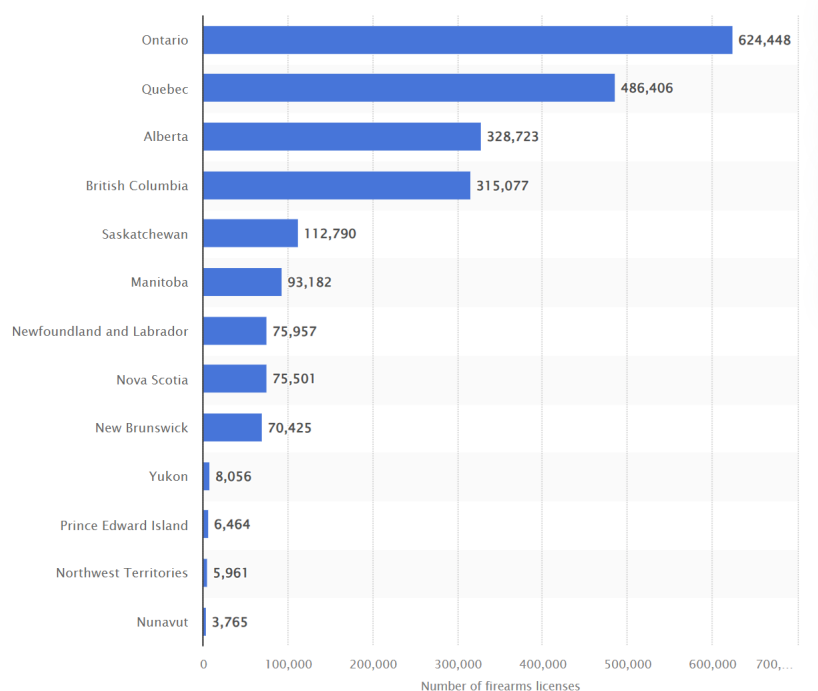


Figure 1: Number of firearms licenses held in Canada in 2020, by province or territory [7]

4.3 US and Global Market

AeroTrack expects significant profitability due to the substantial increase in the number of participants in shooting sports in the United States as of recent years. With more individuals engaging in shooting activities, there is a rising demand for cutting-edge technologies that enhance shooting accuracy and performance. As the shooting sports community expands, enthusiasts and professionals alike seek advanced tools to improve their skills and gain a competitive edge. AeroTrack’s IFOBS can capitalize on this trend by offering user-friendly solutions that cater to the growing customer base. The increasing popularity of shooting sports translates into a larger market for these optics, presenting ample opportunities for growth and higher interest for the company. [8]

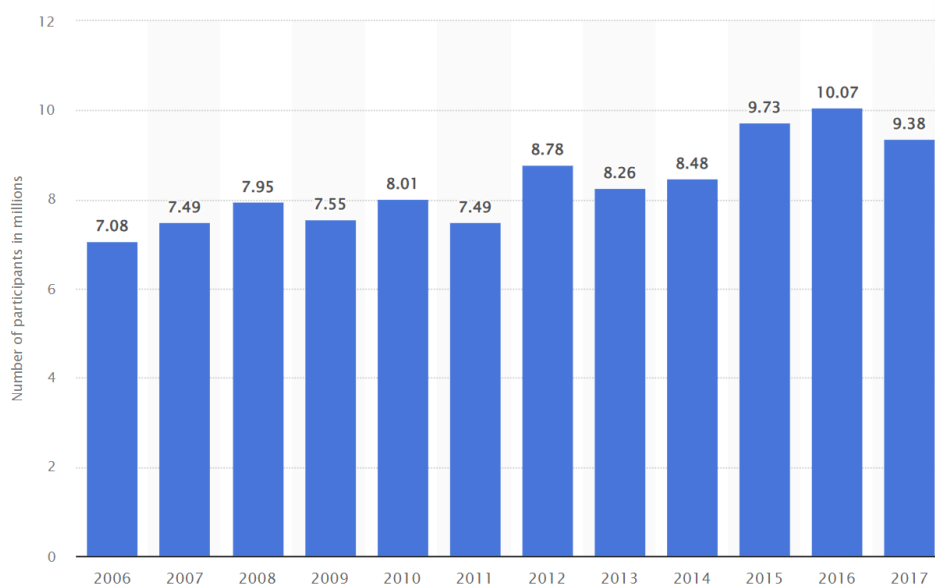


Figure 2: Number of participants in shooting sport in the United States from 2006 to 2017 (in millions) [8]

The global market for rifle scopes is expected to increase significantly, rising from USD \$765.9 million in 2021 to USD \$1,193.6 million in 2028 [9]. For perspective, the US Army’s XM157 fire control optic was awarded USD \$2.7 billion over the next 10 years with an expected 17,164 units to be delivered by the end of 2023 [10]. As the technology becomes more affordable and proven, many shooters from a wide range of experiences will naturally adopt these devices to reduce the complexities of shooting.

4.4 Competition

There are numerous options available in the current scope market to meet the diverse needs of military and civilian shooters. Rifles may be attached with laser rangefinders to provide accurate distance measurements to calculate for bullet drop. Some models include built-in ballistic calculators that consider environmental factors. A recent example is the US Army’s XM157 [2][3], which integrates a laser rangefinder and ballistics calculator, displaying the target’s point of aim. This integration takes place within a standard analog rifle scope.

Vortex Optics - XM157

Vortex Optics is a leading company known for its cutting-edge optical products, established in 2002. Based in Middleton, Wisconsin, USA, the company offers a wide range of high-quality riflescopes, red dot sights, binoculars, and spotting scopes. Vortex Optics achieved an annual revenue of \$24.0M in 2022 [11]. Their dedication to innovation and top-notch craftsmanship has made them a trusted choice among hunters, shooters, and professionals in law enforcement and the military.

The Vortex Optics NGSW-FC, known as the XM157, is a technologically advanced system designed to be mounted on firearms and provide a wide range of functionalities. It will calculate factors such as range, ballistics, atmospheric conditions, direction, and feature digital overlays. The optic will have wireless capabilities to connect with devices like the Integrated Visual Augmentation System. It is intended to replace multiple existing optics and will be initially deployed to close combat forces, including special operations, Marine and Army infantry, combat engineers, and scouts. [13]



Figure 3: Vortex Optics NGSW-FC, known as the XM157 [12]

4.5 Estimated Consumer pricing

Although the XM157 and other similar fire control optics are not available in the civilian market we can estimate the cost per unit price. The podcast from Task & Purpose gives us a good estimate from the promised components. In reality, it's an \$8000 solver and laser, a \$1600 optics package, and a \$1000 custom housing. \$10,000 to \$12,000 would be very reasonable per unit. [12]



Figure 4: Parts and Functionalities included in the XM157 [4]

These assumptions are reinforced from the contract budget with the US military. As reported in Guns.com: “The 10-year contract... covers the production and delivery of up to 250,000 XM157 Next Generation Squad Weapons-Fire Control systems. The NGSW-FC will be the common sight for the Army’s new NGSW-Rifle, set to replace the M4 Carbine in front line service, and the NGSW-Automatic Rifle, the intended replacement for the M249 Squad Automatic Weapon. The contract minimum is set at \$20 million, with a fantastic \$2.7 billion maximum mentioned if all options are taken, pointing to a unit price for each NGSW-FC optic as being in the neighborhood of \$10,800. However, it should be noted that, going past the sights themselves, the contract includes supporting accessories, contractor support, spare parts, repairs, and engineering efforts, likely pointing to a significantly lower per-unit cost than the basic math would imply.” [13]

At AeroTrack we believe we can compete with Vortex Optics by targeting more budget-conscious customers while ensuring many of the essential functionalities are still met. Vortex Optic’s XM157 will be difficult to match in extreme application with its specified range of 1000m. [14] IFOBS aims to maintain the same performance at typical shooting ranges of 100 to 150m. With a price per unit under \$1000, IFOBS will provide customers the same cutting edge technology experience for a fraction of the price.

4.6 Other Major Rifle Scope Manufacturers Competition

The global riflescope market is projected to experience steady growth, with a CAGR of 4.3% during the forecast period from 2023 to 2033. The market’s value is expected to reach US\$ 8.74 Billion by 2033, up from US\$ 5.5 Billion in 2022. The demand for riflescopes is driven by the need for target precision in hand-held weapons and aiming at both short and long distances. However, commercially, riflescopes are restricted in many countries.

Nevertheless, defense organizations in major states are procuring riflescopes to enhance targeting capabilities. The U.S. market is anticipated to witness significant growth at a CAGR of 10.05% due to military enhancements and political conflicts. Technological advancements

in telescopic sights, including electro-optic, thermal imaging/infrared, and laser technologies, are contributing to market growth, catering to various aiming needs, including precision aiming at war locations and shooting sports activities. [15]

Report Attributes	Details
Estimated Base Year Value (2022)	US\$ 5.5 Billion
Expected Market Value (2023)	US\$ 5.74 Billion
Anticipated Forecast Value (2033)	US\$ 8.74 billion
Projected Growth Rate (2023-2033)	4.3%
Expected CAGR of North America	4.6%
Anticipated CAGR of China market	4.4%
Major Riflescope manufacturers	<ul style="list-style-type: none"> • Bushnell Inc. • Leupold & Stevens Inc. • Burris Company Inc. • Vortex Optics • SAM Electrical Equipments Co. Ltd. • Schmidt & Bender GmbH & Co. KG • Hawke Optics • Other Market Players

Table 1: Riflescope Market Outlook [15]

5 Finances

5.1 Cost Analysis

The cost breakdown for each component of the Integrated Fire-Control Optic and Ballistic Solution prototype is summarized in Table 2.

Description	Brand	Product	Price	Number of items	Total Price
Accelerometer	Adafruit	ADXL345	\$25.17	2	\$50.34
OLED Display	Fermion	DFR0934	\$53.51	1	\$53.51
Laser Range Finder	Benewake	TF03-180	\$362.36	1	\$362.36
Header Pins	Lee's Electronic	1x40 Header Pins 2.54mm	\$0.90	1	\$0.90
Rangefinder Connector	Lee's Electronic	JST, GH, 7 Pin, 1.25mm (M/F) connector	\$1.26	1	\$1.26
Optic Perfboard	Lee's Electronic	HS-02	\$2.43	1	\$2.43
Optic screws	Lee's Electronic	M3x20mm screws	\$1.44	10	\$1.44
Optic nuts	Lee's Electronic	M3 nuts	\$0.90	20	\$0.90
Rangefinder screws	Lee's Electronic	Screws M3x8mm	\$0.99	10	\$0.99
Perfboard standoffs	Lee's Electronic	M3x20mm standoffs (M/F)	\$2.70	10	\$2.70
Step Motor PM Geared	NMB Technologies	P14334-ND	\$52.58	2	\$105.16
KIT Motorshield Arduino V2	Adafruit	1528-1187-ND	\$29.74	1	\$29.74
				Total	\$611.73

Table 2: Cost of components

5.2 Funding

With two funding options available 1) Engineering Science Student Endowment Fund (ESSEF) and 2) Wighton Engineering Development Fund we have a chance to secure the financial support needed to develop our innovative "Integrated Fire-Control Optic and Ballistic Solution" under the company name "AeroTrack Research".

1. Engineering Science Student Endowment Fund (ESSEF) - Category B (Entrepreneurial): The ESSEF provides funding for projects falling under the "Entrepreneurial" category. Since our project fits under the following criterias i.e projects that anticipate developing a functional prototype must include a concise Business Plan in their project proposal. The evaluation of proposals will be based on three rating criteria: pragmatism, cost-effectiveness, and vision thus we can apply for funding from this source during the specified application period.
2. Wighton Engineering Development Fund: As mentioned before, we can also apply for funding from the Wighton Development Fund, administered by Dr. Andrew H. Rawicz. Our project, "Integrated Fire-Control Optic and Ballistic Solution," aligns with the fund's goal.

AeroTrack's Integrated Fire-Control Optic and Ballistic Solution (IFOBS) is also poised to attract external funding in future due to the surging Canadian civilian firearm market and the potential interest from investors in the neighboring USA.

6 Project Scheduling

6.1 Gantt Chart

A Gantt Chart is shown in Figure 5 which describes the AeroTrack's processes, goals, and milestones during ENSC 405W. Key deliverables are denoted as milestones and were met throughout the semester.

Capstone Project Planning Gantt Chart

AeroTrack, Company 15

Summer 2023 (May-Aug)

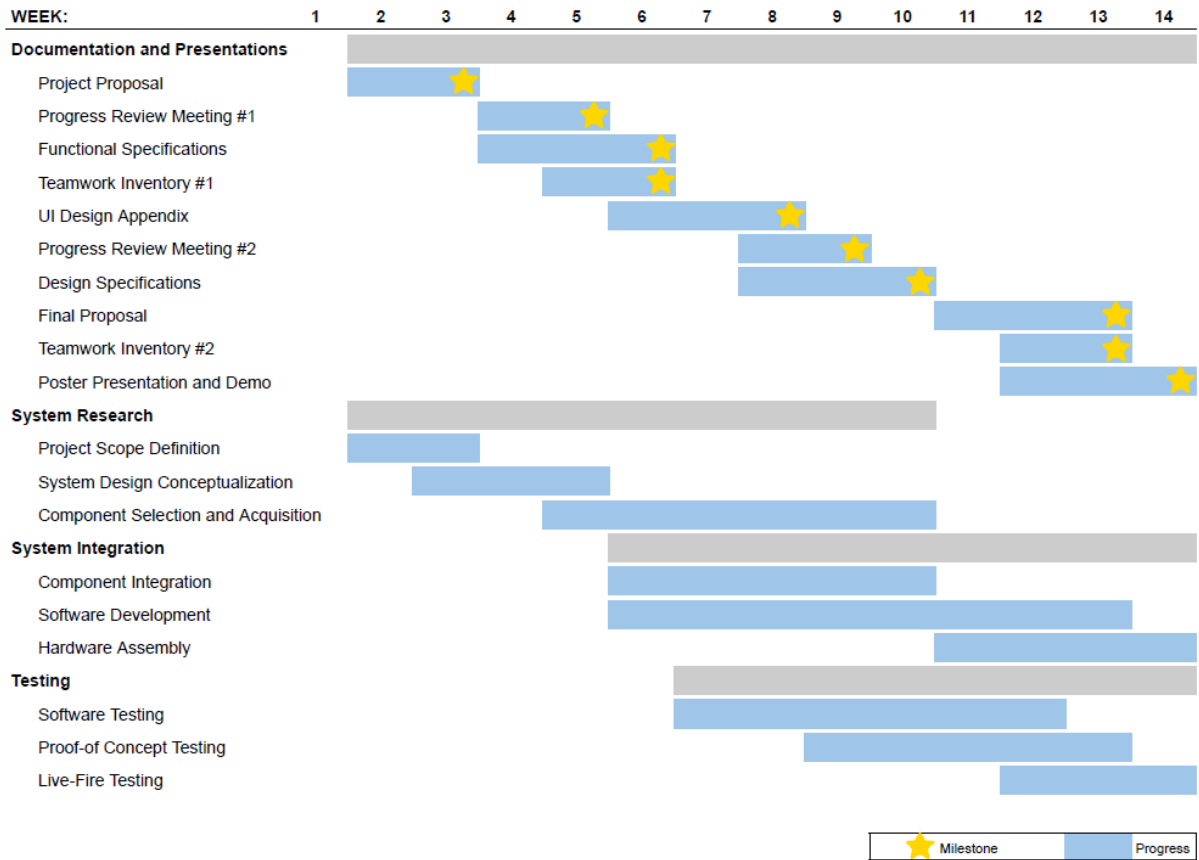


Figure 5: Gantt Chart for the Research and Development of the IFOBS system

7 Company Overview

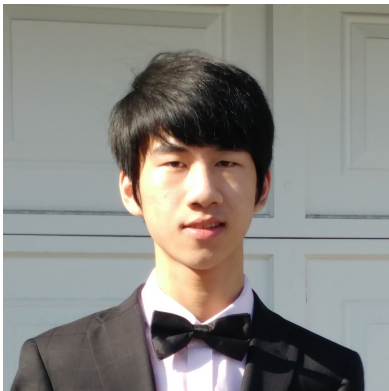
Formed on July 30th, 2023, AeroTrack Research Inc. is a cutting-edge company at the forefront of technological innovation in the riflescope industry. Our mission is to revolutionize both the battlefield and civilian market with our groundbreaking Integrated Fire-Control Optic and Ballistic Solution.

7.1 Meet the Team



Braden Choy
bchoy@sfu.ca
Chief Executive and
Communications Officer

Braden is a 5th year Biomedical Engineering student at SFU with an interest in mechanical design. He is driven to work in the field of developing technology to preserve life. Former experience as a Mechanical Engineer intern at Verathon Medical has provided him insight into technical design and project planning. As an avid sport shooter and team leader, Braden strives to effectively inspire AeroTrack Research Inc. towards success.



Bowie Gian
bgian@sfu.ca
Chief Technology Officer

Bowie is a 5th year Computer Engineering student at SFU with interests in embedded systems design. He has written many modules to interface with components, including a USB host on bare metal ZYNQ-7000 to poll a mouse or drawing tablet. His co-op at Lee's Electronic gave him vast knowledge on electronics and circuitry design. Bowie will use these experiences to ensure successful integration of all the components.



Mint Luc
minh_luc@sfu.ca
Chief Marketing Officer

Mint is a 5th year Computer Engineering student at SFU with interests in Artificial intelligence models. Throughout his co-op position at a real estate company, he honed his skills and wielded the power of AI to revolutionize the prediction of future real estate prices. His aptitude for assessing and selecting the right tools for the task at hand has not only elevated his problem solving skills but also serve as a guiding force, propelling him to conquer the challenges in the industry.



Swapnil Patel
svpatel@sfu.ca
Chief Financial Officer

Swapnil is a 5th-year Systems Engineering student at Simon Fraser University with a passion for oil & gas and marine industries technology. He gained valuable insights during a year-long co-op at Fortis BC, focusing on gas pipelines and safety. Swapnil enjoys football, cliff jumping, and is a nature enthusiast. His dedication and diverse experiences make him a promising candidate for the industry.



Hong Shi
hxshi@sfu.ca
Chief Operations Officer

In his 5th year as an Electronics Engineering student, Hong is passionate about innovative technologies and their societal impact. Previously a Hardware Engineer at Sierra Wireless, he focuses on validating designing and optimizing circuits for signal integrity. Hong's diverse interests include photography and drawing, which provide him with a creative outlet and a balanced approach to life. With his dedication and expertise, Hong is poised to make a significant impact in the field of electronics engineering, shaping the future of technology

8 Conclusion

AeroTrack Research Inc. plans to develop an Integrated Fire Control and Ballistics Solution (IFOBS), which marks a significant advancement in shooting applications. The system's primary goal is to enhance accuracy and marksmanship, making it an indispensable aspect of both military training and shooting applications. By integrating sophisticated technology and innovative design, AeroTrack has created a cutting-edge ballistics tracking system that offers real-time, data-driven insights for precise targeting.

The integration of a laser rangefinder and accelerometer allows the IFOBS to accurately calculate bullet drop points, considering environmental factors and projectile motion principles. This user-friendly and cost-effective solution sets a new standard in the shooting industry and will revolutionize the shooting experience for both professionals and civilian users alike.

AeroTrack's emphasis on simplicity and efficiency is evident in the IFOBS design. The system's intuitive interface enables users to quickly grasp how distance affects the projectile's ballistic solution, enabling them to concentrate on improving shooting form and technique. By eliminating the need for manual trajectory compensation, shooters can focus on hitting their targets with utmost accuracy, even in high-pressure situations. AeroTrack's IFOBS represents a remarkable advancement that empowers shooters and sets a new benchmark for precision shooting technology in the industry.

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