APSC 103

Phase Four Report and Final Design

Team 790-B

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All work in this report is by the listed authors.

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Executive Summary:

The Perfex system serves the purpose of evaluating a 911 operator candidates' ability to effectively handle multitasking while being in a simulated high stress environment. The client, Jenifer Weagle, of the Toronto Police Department tasked the team to create a revised version of the Perfex System. The new system must follow the same format as the original test but should be modified to reflect a modern workplace. The prototype must also be constructed under a $100 budget. This project has been completed by team 709-B. With a thorough timeline including planning, teamwork and organization, the team was able to complete the project. The team was split into hardware and software-specializing teams to complete the project on time.

To complete this project, extensive research was done on the code, hardware, and the psychological aspects of the Perfex test and 911 responders. Research allowed to team to create frontend and backend code, manage Arduino components, and make the modern test more stressful.

An evaluation matrix was used to determine prototype's laptop-Taskbox interface. The user interface includes a main page where you can read the instructions and has a button to start the test. A timer starts once the start test button is clicked, and the user must navigate though individual testing five distinct modules. After all tests are completed, the user is prompted with a button that marks all online tests. In addition, the TaskBox has its own test and grading run through the Arduino separate to the interface. The prototype aligns with all functional requirements; however, many improvements should have been made for professional usage. With more time, aspects such as integrating the Arduino code into the JavaScript and interface would be able to be completed.

The device implemented a web-based interface that streamlined grading and eliminated a need for paperwork. Environmental and societal factors were considered through ensuring equity in the selection process for the test and eliminating paper to align with environmental sustainability goals. The project did not require traditional quantitative models due to the focus on software and Hardware processing. However, third-party testing was done to validate the prototype's performance.

Team organization was accomplished with the use of a work breakdown structure and Gantt chart. A risk analysis chart was designed to predict obstacles during prototype construction while offering concise mitigation tactics. A financial analysis was conducted to record all expenses required for the prototype's construction. The team was able to stay under the budget of $100 by only spending $92.18. As well team created a breakdown of future costs for the client if they choose to make improvements. The probability of the prototype is not really considered since the Toronto Police Department using this for revenue, and more for the greater good of the city.

Finally, the success of the Perfex prototype was evaluated in multiple ways. Various data sets were collected from the third-party testers, this data was analyzed through the evaluation rubric created. Fortunately, it received a score of 80% which bypassed the 75% threshold outlined in Phase three Report.

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1. Key Client Information

1.1: Problem Statement and Scope Definition

Communication services are pivotal towards reliable emergency response services. With a daily rate of approximately 3,250 urgent calls a day within the Toronto Police Department, 911 operators are expected to diligently extract caller information and guide dispatching services. However, since calls are frequently presented under unfamiliar and intensive conditions, it is important to hire operators that are proficient in multi-tasking, auditory perception, and stress management [1].

To select suitable candidates for communication services, the Toronto Police Department has relied on “Perfex”: a multi-tasking device that uses various modules to examine one’s resilience, speed, accuracy, and attention to detail under stressful conditions. The department acknowledges that Perfex’s development in the 1970s hinders its ability to reflect a modern workplace and its technology. This is why an updated version of Perfex with a modern automated grading system, web-based-interface, and typing module has been requested and completed to assess candidates’ ability to be a 911 operator.

To successfully complete the APSC 103 design project, a scope has been designed to outline objectives that can be accomplished over the course of the semester. In this specific project, the client has set clear expectations of having a functioning 911 responder testing machine prototype. With thorough planning, teamwork and adhering to the project timeline, creating a functioning prototype was accomplished.

The people who worked on this project include students XXXX, XXXX , XXXX, XXXX, and Julien Chagnon. To create the functioning prototype, team members skills were used optimally. First, team members XXXX, XXXX, and XXXX used their strong coding skills, and coded the entirety of the frontend and backend of the projects interface. Next, team members Julien and XXXX used their Arduino and hardware skills to design and implement hardware aspects in the project. Finally, all members used their communication and teamwork skills with the team, project manager, faculty advisor, and client to complete the project.

With the new Perfex prototype developed, there were multiple constraints that were tackled. One constraint included the budget for the prototype being $100. Fortunately, the team was able to stick to the budget and did not require extra financial support. Additionally, as requested by the client, the team was challenged to make creative and modern improvements while adhering to Perfex’s original layout, marking scheme, and design. Some key requirements that were included are having the test be 30 minutes, having certain memory activities, calls from a telephone, and many more. Finally, one constraint worth noting is that the test must be designed to be difficult: no candidate should be able to receive a perfect score. This was considered when creating the code and developing the final prototype.

With the development of any product, research and learning are very important in the prototyping phase. Lots of skills such as coding algorithms, Arduino circuitry and implementing them together were learnt to successfully create a functioning prototype. Fortunately, many online resources such as YouTube, Google, Udemy, and Coursera were able to be used to refine skills.

1.2 Background Information

In crafting the Perfex system tailored for evaluating potential 911 dispatchers, several resources have significantly shaped its design and functionality, ensuring it mimics the high-pressure environment of emergency response roles. Among the resources is "Arduino Applied" by Neil Cameron [4] which was often referenced during the creation of the physical component of the Perfex system as it provided the knowledge and steps to set up working physical functions using the Arduino Uno. B. YouTube videos, such as SuperSimple Dev's “HTML & CSS Full Course – Beginner to Pro” and Adam Thomas' “Communicating between an HTML/Javascript interface” were used to develop well-structured code for Perfex's testing modules. The Perfex system required coding skills that were unknown before, however this text proved useful as it provided knowledge in the HTML, CSS, and JavaScript. Such knowledge was used significantly during the construction stage of the system. The contents of the study "Job Stress Effects on Job Satisfaction and Attrition in 9-1-1 Call Centres" were used during the creation of the tests to make the tests more stressful resulting in more accurate test results. Andre Jucovsky Bianchi's and Marcelo Queiroz's “Real time digital audio processing using Arduino” provided information on how to capture and emit audio using an Arduino and was used when building parts of the physical component. Overall, the knowledge gained from these ressources was critical in creating the prototype.

1.3 Design Solution

The solution created includes a Laptop-Taskbox design as seen in Figure 1.

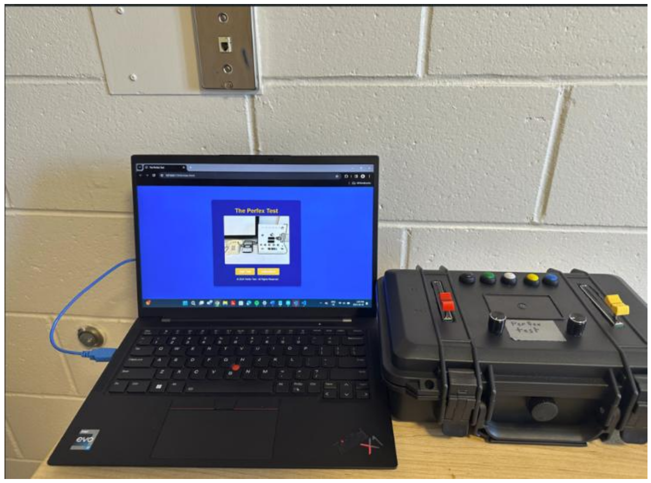

Figure 1: Final Laptop-Taskbox prototype including user interface and the Taskbox

To start, all paper and handwriting aspects have been removed from the original test and have been implemented into an all-in-one interface. This interface includes all audio, digital notetaking, answer boxes and the map-index. The Perfex test starts with its own landing page where the user can click a button to read the instructions and a button to start the test. The test has been adjusted to a module-by-module structure where the candidate must complete a given test to unlock the next one. After the start test button is clicked, the user is redirected to the modules page where the first module unlocks, and the timer starts. Pictures of the home page and module page can be seen in Appendix 1

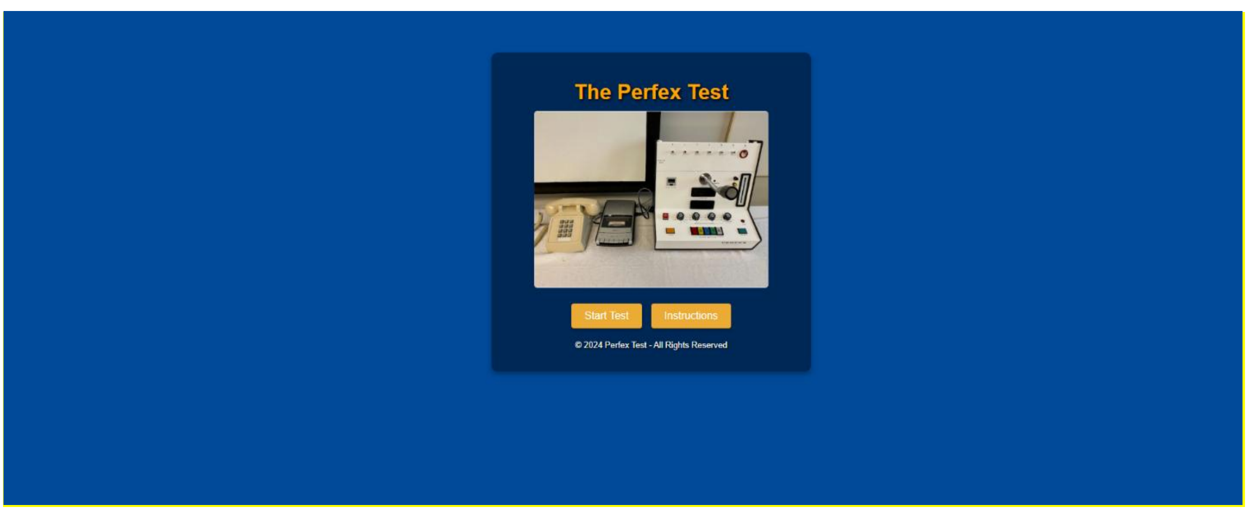

Figure 10 and Figure 11 found in

References

[1] C. Wilson, "911 call wait times are on the rise in the Toronto-area," 26 August 2023. [Online]. Available: https://toronto.ctvnews.ca/it-was-just-horrible-911-call-wait-times-are-on-the-rise-in-the-toronto-area-1.6535981.

[2] "TORONTO CRIME RATES IN 2023," Vilkhov Law, 13 09 2023. [Online]. Available: https://vilkhovlaw.ca/toronto-crime-rates/. [Accessed 16 02 2024].

[3] Sweetwater, ""Should I record at the high sample rates?," inSync, [Online]. Available: https://www.sweetwater.com/insync/should-i-record-at-the-high-sample-rates/#:~:text=For%20mastering%2C%2096kHz%20or%20even,d%20get%20at%20higher%20rates. [Accessed 17 02 2024].

[4] N. Cameron, "Arduino Applied: Comprehensive Projects for Everday Electronics," O'Reilly, 2019. [Online]. Available: htpps://www.oreilly.com/library/view/arduino-applied-comprehensive/9781484239605/html/4741900_1_En_1_Chapter.xhtml. [Accessed 26 01 2024].

[5] B. Harwani, Practical C Programming: solutions for modern C developers to create efficient and well-structured programs, 1st edition, Birmingham, UK: Packt Publishing, 2020.

[6] D. Gilligan, Job stress effects on job satisfaction and attrition in 9-1-1 call centres, Florida, US, 2020.

[7] T. R. Kuphaldt and J. Haughery, Applied Industrial Electricity, Iowa State University Digital Press, 2020.

[8] A. Bianchi and M. Queiroz, "Real time digital audio processing using Arduino," University of Sao Paulo, Sao Paulo.

[9] "Who governs the police?," settlement.*org*. https://settlement.org/ontario/legal services/police/police-basics/who-governs-the police/#:~:text=Ministry%20of%20the%20Community%20Safety (accessed March 25, 2024).

[10] "HTML & CSS Full Course - Beginner to Pro (2022)," www.*youtube.com*. https://www.youtube.com/watch?v=G3e-cpL7ofc

[11] "Communicating from an Arduino to an HTML/JavaScript Webpage," www.*youtube.com*. https://www.youtube.com/watch?v=gQYsUjT-IBo

Appendix 1.

The first module includes Part A of the Short Story Test, where an audio file is played and the user is provided an opportunity type notes. The second module includes the Reading Aloud Test, where the user is prompted to hit a record button and say all the sentences on the screen and then click submit. The third module includes the Copying Information test where the user plays the audio file and enters all the combinations, phrases, and sentences in the input box. The fourth module includes the Telephone Call Test where the user must listen carefully to the telephone call and enter required information in the input boxes. The fifth module includes the Part B of the Short Story Test where the user can see their notes from before and are prompted to answer questions from the short story. Finally, the last module includes the Map Index Test where the user must listen to the audio and find specific addresses. These online tests can be seen in Figure 12, Figure 13, Figure 14, Figure 15, Figure 16 and Figure 17 found in

References

[1] C. Wilson, "911 call wait times are on the rise in the Toronto-area," 26 August 2023. [Online]. Available: https://toronto.ctvnews.ca/it-was-just-horrible-911-call-wait-times-are-on-the-rise-in-the-toronto-area-1.6535981.

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[11] “Communicating from an Arduino to an HTML/JavaScript Webpage,” www.*youtube.com*. https://www.youtube.com/watch?v=gQYsUjT-IBo

Appendix 1.

Once all online tests are completed, the user is prompted to click an end test button, which then grades all modules and shows the user's score. At the instant, the final score is presented to the user for demonstrative purposes but can be easily hidden in an exterior text file for private access by graders if needed. The scoring can be seen in Figure 18 found in

References

[1] C. Wilson, "911 call wait times are on the rise in the Toronto-area," 26 August 2023. [Online]. Available: https://toronto.ctvnews.ca/it-was-just-horrible-911-call-wait-times-are-on-the-rise-in-the-toronto-area-1.6535981.

[2] "TORONTO CRIME RATES IN 2023," Vilkhov Law, 13 09 2023. [Online]. Available: https://vilkhovlaw.ca/toronto-crime-rates/. [Accessed 16 02 2024].

[3] Sweetwater, ""Should I record at the high sample rates?," inSync, [Online]. Available: https://www.sweetwater.com/insync/should-i-record-at-the-high-sample-rates/#:~:text=For%20mastering%2C%2096kHz%20or%20even,d%20get%20at%20higher%20rates. [Accessed 17 02 2024].

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[6] D. Gilligan, Job stress effects on job satisfaction and attrition in 9-1-1 call centres, Florida, US, 2020.

[7] T. R. Kuphaldt and J. Haughery, Applied Industrial Electricity, Iowa State University Digital Press, 2020.

[8] A. Bianchi and M. Queiroz, "Real time digital audio processing using Arduino," University of Sao Paulo, Sao Paulo.

[9] “Who governs the police?,” settlement.*org*. https://settlement.org/ontario/legal services/police/police-basics/who-governs-the police/#:~:text=Ministry%20of%20the%20Community%20Safety (accessed March 25, 2024).

[10] “HTML & CSS Full Course - Beginner to Pro (2022),” www.*youtube.com*. https://www.youtube.com/watch?v=G3e-cpL7ofc

[11] “Communicating from an Arduino to an HTML/JavaScript Webpage,” www.*youtube.com*. https://www.youtube.com/watch?v=gQYsUjT-IBo

Appendix 1.

Next, physical, and manipulative tests have been moved into their own section of the test comprised within the Taskbox. This part of the test will be completed after all the online tests are completed. **Error! Reference source not found.** shows a photo of the finalized Taskbox when connected to a laptop via USB, and Figure 2 shows an inside view of the TaskBox. The test conducted through the Arduino-based system comprises a series of rapid randomized instructions that the user must complete one at a time in minimal time and with accuracy. Examples of such instruction would be as simple as pushing buttons sequentially, turning knobs to reach integer values and pushing sliders up or down. The user is graded automatically based on reaction time and precision on each instruction to add up a final score out of 19.5, which can either be displayed to the former or stored as a variable for secrecy. Another important factor is the test's scalability, as it can be lengthened or shortened easily by varying the number of instructions presented. As it stands, a typical test lasts around 5 minutes as each unique instruction is presented and graded once. As for changes made to the physical prototype, the choice to drill holes into the briefcase lid and display sensors from the inside was taken due to the structural support that the plastic offered while operating the buttons, which are hard to press. Opting for the earlier conclusion of a 3D printed support would have introduced the possibility of structural failure and elastic deflection from the support while buttons were pressed, affecting desired functionality. The design decision was chosen to mitigate these risks.

Figure 22: Constructed prototype for physical aspect of testing phase

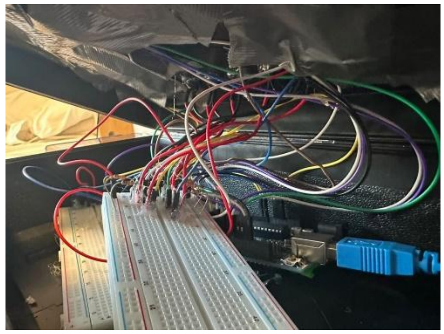


Figure 3 3: Inside view of constructed Taskbox. Arduino breadboards and wires are visible.

With the new prototype completed, a variety of things will be given to the client. First, access to a GitHub repository including the CSS, JavaScript, HTML, Audio and Pictures will be provided. In addition, the physical Taskbox including all electrical components and Arduinos will be provided.

There are several steps the client will need to take to implement the solution. First, they will have to purchase a domain for the test so that it can be accessed on the web. Second, they will have to create a server/database storing scores and other important information from the test. Third, the client will need to create a refined version of the Taskbox, implementing the same schematics, however on a soldered PCB instead of just using a breadboard. Costs for all three of these steps must be incurred to create the final product. These prices will vary depending on how much they are willing to spend. In addition, integrating the physical test into the website can be added if wanted.

1.4 Conclusions

The updated Perfex prototype represents a substantial step forward in modernizing the Toronto Police Department's 911 dispatcher assessment process if implemented on a larger scale. The transition to a digitized test format with automated grading significantly reduces administrative burdens and improves evaluation efficiency. The accompanying Taskbox effectively simulates the multitasking challenges and stressful conditions inherent to the role, providing valuable insights into a candidate's suitability.

Although the final product functions as intended, it is just a prototype and could greatly benefit from additions and modifications to the overall system. These were not able to be added due to the constraints on time and resources. For instance, while the digital and physical components both function properly, they were unable to be integrated together before the Phase Four submission. It is highly recommended that the client finishes this task before it can be properly implemented. Some modifications that could be added include improving the flow of the test to make it more continuous then the current version, using higher quality materials for the physical components of the test, making the experience easier for the user, adjusting the automated grading system to fit how the client prefers the test to be graded and, improving or adjusting the design of the website to the design of the clients choice to better fit their brand. All these additions could all improve the system as a whole.

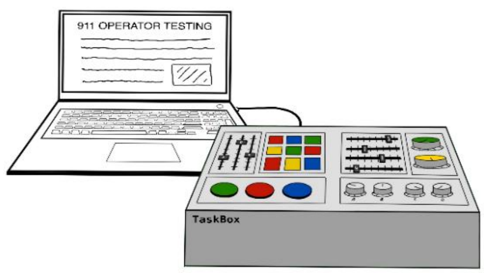
2. Technical Information

2.1 Conceptual Design Solutions

In evaluating alternative design solutions for a 911 Operator Testing Machine, three distinct approaches presented themselves. Each design offered unique advantages and challenges, particularly in usability, cost, and the integration of physical and digital components.

The first design, shown in

Figure 4, consists of a laptop and a Taskbox with Arduino-powered knobs, sliders, and switches. The Arduino-based Taskbox was designed to match the functionality of Perfex's predecessor in terms of user input. Visuals, results, and audio cues for the test were intended to be provided by front-end programming languages (JavaScript, HTML, and CSS) on the laptop. This design's larger project scope equally distinguishes and challenges the strengths of all team members, thereby enforcing a stronger



learning experience.

Figure 4: Conceptual sketch of the laptop-Taskbox Interface by XXXX; the Taskbox should align with the dimensions declared in Section 1.3.4

Figure 5 shows a design that integrates a Taskbox, LCD screen, and miniature keyboard to a hardshell case to entice a portable iteration of the first design. Since all components are oriented around Arduino programming languages, a learning of any front-end programming languages would not be needed. With its focus on a single programming language, this design is advantageous as it would alleviate the magnitude of the team's project scope.

Figure 55: Conceptual sketch of the portable Taskbox designed by XXXX. A miniature keyboard, LCD screen, and Taskbox was designed to fit inside of a foldable case, thereby assisting in portability.

Finally, a software-centric design shown in Figure 6 discards physical components in favor of a digital interface managed entirely through a laptop's mouse and keyboard. This design aims to simplify deployment and reduce costs by focusing on software development without the need for manufacturing physical testing apparatuses. While this design would terminate costs for physical components, it fails to align with the strengths of some team members. Selecting this design could create an unfair work environment that would pose a hindrance to the team's progress.

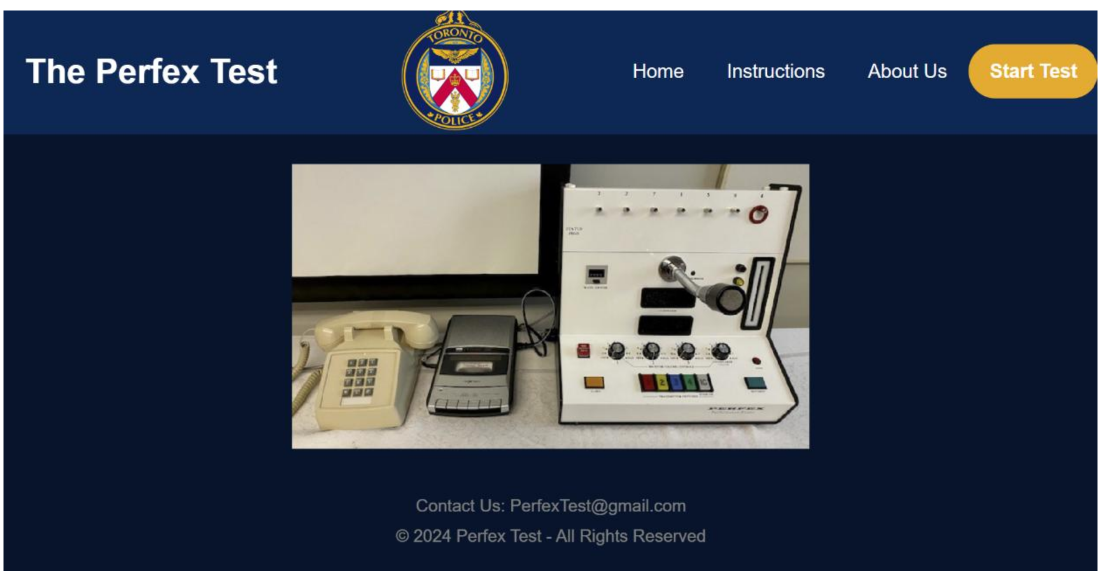


Figure 6: Prototype homepage for a software oriented Perfex model. This webpage was designed using HTML and CSS and was later used to structure the final prototype's main page.

2.2 Decision Making

The designs proposed in Section 2.1 offer a unique set of challenges that can drastically influence the outcome of the delivered product. The team developed evaluation matrix in Table 1 to ensure that the selected design mitigated any constraints posed in Section 1.1 while aligning with the team's goals, characteristics, and interests. Although each concept will be weighted differently, they will consistently be marked on a score from 1-5. Designs that successfully adhered to each corresponding concept were presented with higher scores.

Table 1: Evaluation Matrix that was used to determine Perfex's final design.

Weight (%)	5	5	5	5	10	10	10	15	15	20	
Design	Portability	Costs	Environmental Impact	Accessibility	Time Investment	Alignment with Team Strengths	Future Benefit	Maintenance	Ease of Assembly	Interest Factor	**TOTAL SCORE (%)**
#1. Laptop-Taskbox Hybrid	3	3	2	3	3	5	5	3	3	4	71.0
#2. Portable Taskbox	5	1	2	3	3	4	3	1	1	4	53.0
#3. Software-Oriented Design	4	5	5	4	1	1	3	2	4	2	54.0

When challenged by the constraints highlighted in the evaluation matrix, the laptop-Taskbox interface asserts itself as the most effective and well-rounded design. It's higher score of 71% is denoted by its ability to achieve higher scores for weighted categories (i.e. Team Strength Alignment, Future Benefit, and Interest Factor). It counters the budget constraint by using parts that can be borrowed (such as the Arduino Uno), are already owned (like keyboards, monitors, laptops), and be purchased for a low price (the earpiece). The design retains the concept of the original Perfex system while updating and reinventing components to create the modern feel and improve the overall performance of the system. The concept also aims to transfer the old, outdated machine into a more digital and lightweight system where the machine can be easily transferred, and content can be easily updated and changed through the addition of the laptop. Finally, it's capability to incorporate both hardware and software presented a rewarding challenge that piqued the team's interest. This concept was weighted the heaviest as it dictated team morale and would therefore alter the outcome of the final prototype.

Overall, the design chosen covers all constraints presented while creating a more modern system which is easy to use and modify and make the overall marking system easier on the proctor.

2.3 Implementation

This section outlines the work completed since the Phase 3 proposal and highlights key changes made to the original design for any reason. The core design solution of a laptop-Taskbox system remains unchanged. All modules have been converted into a web-based interface for streamlined testing and automated grading. This eliminates manual paperwork and improves efficiency for both candidates and administrators. Tests are now presented sequentially, ensuring focus on individual tasks for an improved candidate experience. Additionally, the physical Taskbox provides tactile feedback and a hands-on experience for testing. Ensuring that candidates can perform in every aspect of the simulation including both reaction time through the physical prototype and critical thinking and communication through the software-based evaluations was a key factor in the construction of our model.

Environmental and societal factors were also kept in mind in the construction of the updated design. The digitized interface offers the ability to incorporate possible accessibility features, ensuring equity in the selection process. Eliminating paper-based needs aligns with environmental sustainability goals as a society. Additionally, the automated grading system aims to minimize potential human bias in scoring, promoting a fairer assessment process for all candidates.

Given the project's focus on software and hardware processing, the team was unable to evaluate the prototype using traditional quantitative models (i.e. free-body diagrams, stress-strain analyses, or evaluation services on SolidWorks). Such an obstacle for data was combatted through an implementation of a survey (Figure 19) and evaluation rubric (Table 7: Evaluation rubric) that were distributed to eleven third-party individuals (Sam Lee, Tal Shram, XXXX Parsons, Mattias Voogd, Jillian, Alisa Bressler, Kailey Bressler, Jacob Tam, Ethan Brennan, Fraser Canavan and Charlie Stuart). Thorough testing of the final prototype to validate its performance against the functional specifications will be detailed in Section 2.4 of this report.

While intensive in-depth modelling was beyond the scope of this project, future work could involve a deeper mental analysis through advanced real-life simulations. Complex dispatch scenarios would effectively give the client a better idea of the individual's performance in high-stress situations where the public's safety is put on the line.

2.4 Project Plan and Application of Risk Mitigation

Time management is critical towards the success of Perfex's design and performance, regardless of what experience the team has in terms of Arduino modelling and coding. An updated work breakdown structure and Gantt chart shown in Table 2 and

Figure 7 model a timeframe for the client presentation, Phase 5 report, or any urgent fixes if needed. As per the contract addressed in previous reports, team members are expected to complete each task within the allotted timeframe.

Table 2: An updated Work Breakdown Structure that outlines all tasks that are be completed before the end of APSC 103

Task or Activity Identifier	Task Description	Expected Duration (Days)	Activity Leader
1	**Finalize Prototype**	**16**	
1.1	Reassess/edit all prior sections according to Phase 3 feedback provided by Communication TA Hanna Gamelin	4	All
1.2	Test and debug prototype, apply mitigation strategies presented in Phase Three report if possible	15	Julien, XXXX, XXXX
1.3	Describe implementation process for both hardware and software in Phase Four Report	3	XXXX, XXXX, Julien
1.4	Perform a financial analysis on Prototype	1	XXXX
1.5	Conduct a quantitative and qualitative analysis on the prototype; use evaluation matrix in Section 2.2 to determine if the Perfex prototype is satisfactory	2	XXXX, Julien
1.6	Document results and conclusions in Phase Four draft, submit to Project Manager XXXX for feedback	4	All
1.7	Rewrite Phase Four Report according to PM feedback	7	All
2	**Present Finalized Product**	**9**	
2.1	Arrange meeting with client	1	XXXX
2.2	Create slides for client presentation	3	XXXX
2.3	Practice prototype demonstration and presentation	2	All
2.4	Present prototype to client	1	All
2.5	Draft/edit Phase 5 Report and reflect on presentation	7	All

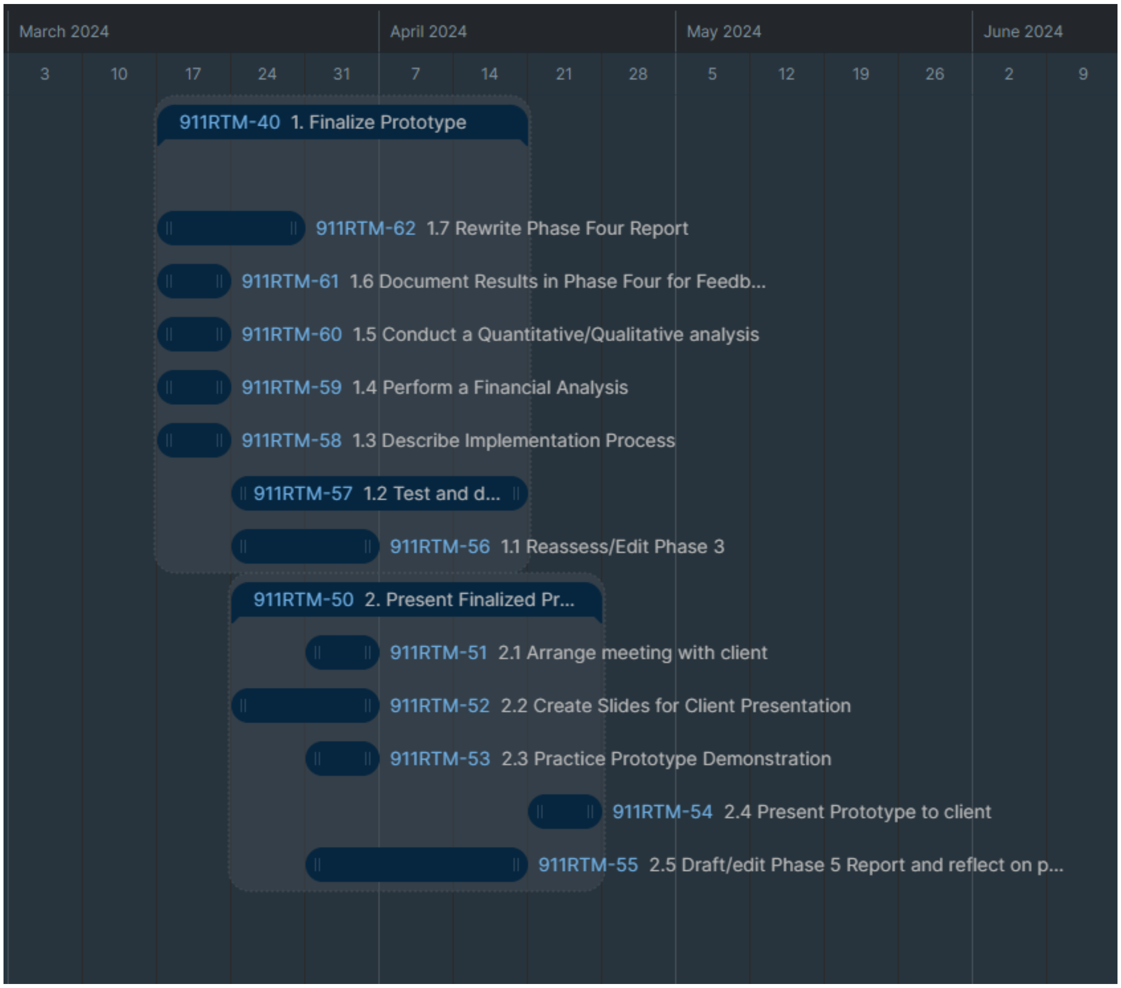


Figure 7 7: A YouTrack Gantt Chart that assists in visualizing the timeframe of the tasks that were outlined in the Work Breakdown Structure.

APSC 103 defined project risk as an "action or event that contributes to the likelihood that a project will fail to meet its objectives" and risk assessment is based on likelihood and magnitudes that vary across different engineering fields. To prevent a case of physical harm, safety concerns in T. Kuphaldt and J. Haughery's "Applied Industrial Electricity: Theory and Application" were considered. In accordance with the criteria presented for the Phase Three report, risks in terms of functionality were considered to evaluate the prototype's success. Identified risks for both categories were compiled in **Error! Reference source not found.**the table below to alleviate the likelihood or degree of each problem.

Table 3: A Risk Analysis chart that predicted the likelihood and magnitude risks during prototype construction. Proposed solutions for each identified risk were outlined on the right.

Identified Risk	Cause of Risk	Likelihood and Magnitude Rating (1 - LOW, 5 - HIGH)	Proposed Solution
1. Electrical Shock due to high current	Occurs when client gets in contact with the prototype's electrical components. Magnitude is dependent on current running through the circuit.	Likelihood: 2.0 Magnitude: 4.0 **OVERALL: 3.0**	Ensure prototype is insulated, incorporate strategies from "Applied Industrial Electricity" (i.e. wearing insulating gloves while modifying the circuit, reducing current with resistors, ensuring prototype is unplugged while being modified).
2. Incompatibility between hardware and software/ ~5 second response encountered in modules	Caused by poor communication between team members. Can also be caused through unfamiliarity in code.	Likelihood: 2.5 Magnitude: 5.0 **OVERALL: 3.75**	Maintain communication between software and hardware sub teams, discuss concerns with upper year computer engineering students, research JavaScript and Arduino compatibility.
3. Occurrence of logical, run-time, or compilation errors in code	Expected to be a commonality when designing code but will pose a greater risk as the prototype's due date approaches.	Likelihood: 5.0 Magnitude: 1.0 **OVERALL: 3.0**	Have all team members analyze code and propose solutions, participate in APSC 142 Helpdesk sessions, have some leeway for debugging.
4. Defective Arduino or hardware components	Can occur through rigorous or uneducated testing procedures. The quality of provided Arduino components is another factor to consider.	Likelihood: 1.25 Magnitude: 2.25 **OVERALL: 1.75**	Have an extra supply of components, design the prototype so that it is easy to modify, keep in touch with Aphra ahead of time.

Given Perfex's large project scope, many predicted risks were encountered during the prototype's construction. A Risk Evaluation Log (Table 4) was created to concern how the team confronted common issues and if their efforts were deemed successful.

Table 4: A Risk Evaluation Log that recorded how Team-790B managed predicted risks and errors. Applied Mitigation Tactic(s) are displayed on the right and the outcome of each tactic was outlined accordingly.

Encountered Risk	Team Member(s) Who Reported/Resolved Risk	Reason Behind Risk	Applied Mitigation Tactic(s)
Occurrence of logical errors in code, thereby interfering with the web pages appearance and functionality.	XXXX, XXXX, XXXX	Inexperience with HTML, CSS, and JavaScript as intertwined programming languages.	SuperSimpleDev's "HTML & CSS Full Course – Beginner to Pro" was studied to assist with the webpage's appearance and functionality. Efforts towards fixing code were immediately implemented when a problem was encountered. *Mitigation was Deemed Successful*
Difficulties activating Arduino components, specifically sliders and knobs.	XXXX, Julien	New hardware required unfamiliar code and wiring techniques.	Resources from previous reports (i.e. N. Cameron's "Arduino Applied: Comprehensive Projects for Everyday Electrons") were studied to program/setup knobs and switches. *Mitigation was Deemed Successful*
Accidental use of a defective 3D printer.	XXXX, XXXX, Julien	Transportation of device disconnected cables and caused its filament extruder to malfunction.	Repairs were attempted but unsuccessful. The STL model designed by XXXX was discontinued. A new physical case was purchased and altered with drills and saws. *Mitigation was Deemed Successful*
Incompatibility between hardware and software	XXXX, Julien	Time constraints and overall inexperience with integrating Arduino with JavaScript.	Adam Thomas' video: "Communicating between an HTML/JavaScript Webpage and an Arduino" was watched for suggestions. *Mitigation was Deemed Unsuccessful*

2.5 Financial Plan Analysis

To make a functioning prototype, a variety of expenses were incurred. Table 5 shows a financial breakdown of all costs incurred to create the prototype.

Table 5: Financial breakdown of items to be purchased.

Items	Product	Price	tax	Shipping	Net cost
Headset	Logitech H111 Headset	$19.98	$2.60	Free	$22.58
Buttons	5PC Illuminated Push Buttons	$12.26	$1.60	Free	$13.86
Wires	Dupont Wires Male to Female and Male to Male	$8.99	$1.17	Free	$10.16
Sliders	DAOKI Logarithmic Slide Potentiometer	$22.99	0	Free	$22.99
Dials	WMYCONGCONG 360 Degree Rotary Encoder Module	$19.99	$2.60	Free	$22.59
Total		**$84.21**	**$7.97**		**$92.18**

As seen, buttons, a headset and wires were needed to be purchased to construct the prototype. All other materials were either re-used from the course APSC 101 or were already owned by team members. Most of the software aspects to make the interface did not require any financial loss.

Financial considerations were carefully evaluated for the product, yet they played a comparatively minor role in the overarching project objectives. As seen in Table 5 the product involved acquiring specific components such as sliders, dials, buttons, and a headset, which are all essential for the prototype's functionality. The total cost for these newly purchased items amounted to $92.18, which was comfortably within the project's modest budget of $100. Also, the project used available materials, such as a hardcase box, wires, and a breadboard. The decision to incorporate these existing resources further minimized costs, demonstrating a resourceful and efficient use of materials.

If the client were to implement this solution, a variety of costs would be required. This includes domain server, new electrical components, PCB boards, Arduino's and many more. The following

Table 6 shows these future costs.

Table 6: Financial breakdown of items to be purchased for an official Perfex model.

Items	Product	Price	tax	Shipping	Net cost
Cloud Server	Cloud server for the Toronto Police Department to run the website	$60/annum	0	0	$60/annum
Domain	Domain for the website to be hosted on the internet	$15/annum	0	0	$15/annum
PCB Board	Miuzei PCB Prototype kit	$21	$2.73	Free	$23.73
Arduino Uno	A000066 Uno R3 DIP Edition	$30	$3.90	Free	$33.90
Buttons	5PC Illuminated Push Buttons	$12.26	$1.60	Free	$13.86
Wires	Dupont Wires Male to Female and Male to Male	$8.99	$1.17	Free	$10.16
Sliders	DAOKI Logarithmic Slide Potentiometer	$22.99	0	Free	$22.99
Dials	WMYCONGCONG 360 Degree Rotary Encoder Module	$19.99	$2.60	Free	$22.59
Pelican Case	Pelican 1120 Case with Foam (Black)	$46.69	$6.97	free	$53.66
Total		**$236.92**	**$18.97**		**$255.89**

However, there are a variety of financial benefits that can be considered. The Toronto Police Department can sell this test to other police forces nationally, or even internationally. However, since the Toronto police department is a non-for-profit organization, and is funded municipally, financial gain from the Perfex test is not prioritized [9].

2.6 Evaluation

Evaluating the success of the Perfex prototype involved a thorough assessment against the objectives and quantifiable functional specifications set forth in Section 1.1. The goal of the design was to create a modern and updated version of the old system being used while keeping the same general components and processes used in the original model. The evaluation rubric displayed in Table 7 was the primary tool used to guide this assessment. The rubric quantified the final prototype's ability to follow Perfex's original layout, marking scheme, and design requirements to a considerable extent. It was also used to analyze the final prototype's visual aesthetic and ability to minimize hazards/risks for the client.

Upon its completion, the prototype was thoroughly assessed with the evaluation rubric and an overall score of 80% (12/15) was achieved. With such score in mind, the team successfully bypassed the 75% goal that was outlined in the Phase Three Report.

The prototype boasts a strength in design specifications, notably through its sub score of 90% (4.5/5). It almost acts exactly like its 1970s predecessor, it is lightweight, and has responsive cues. A perfect score would have been achieved if the auto grading was made to be adaptable and case insensitive. Additionally, the prototype's appearance was given a sub score of 80% (4/5) and was deemed to be satisfactory. A higher score could be achieved if the prototype's Arduino interface was designed to be less confusing. Finally, with sub score of 70% (3.5/5), it was discovered that the prototype faltered in its ability to mitigate potential risks. A higher score would have been achieved if the team was able to achieve Taskbox-webpage compatibility before Phase Four's submission date.

In retrospect to Section 2.2, data from Figure 19's survey was compiled into Figure 8 and Figure 9 to provide a visualization of the prototype's success in particular categories. The client may refer to this data if they wish to make improvements to the prototype.

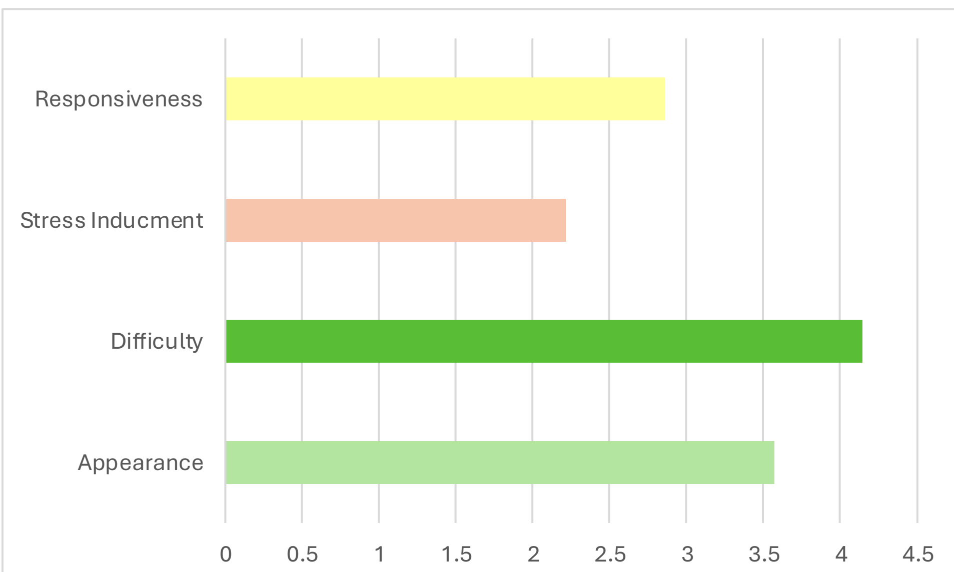


Figure 8: Rating of the final prototype based on the results from the survey given out (Figure 19).9

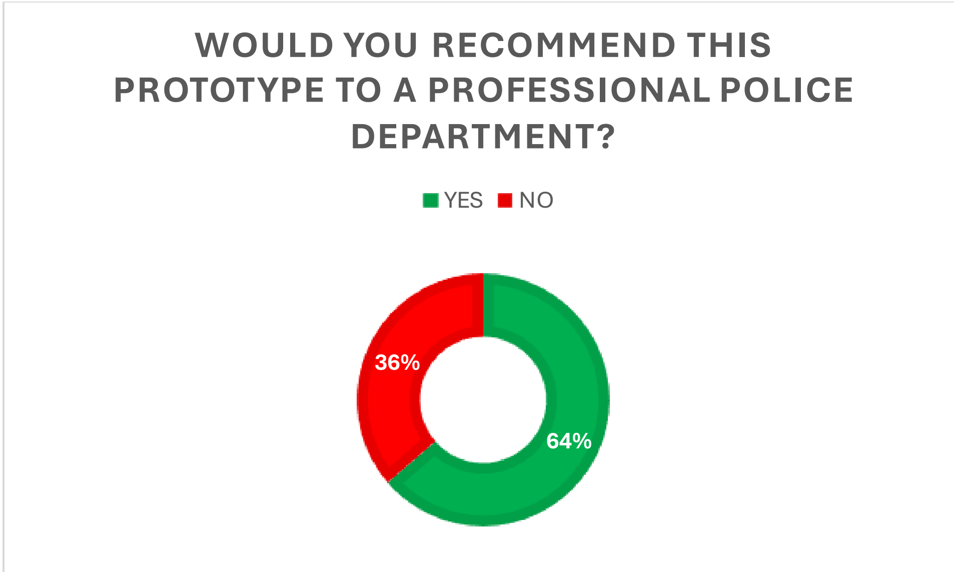


Figure 910: Survey Results of "Would you recommend this prototype to a professional police department?"

The experimental data displays how the prototype holds strong in terms of its appearance and difficulty, providing further evidence of its ability to adhere to design specifications. The prototype's lower rankings in stress inducement and responsiveness reflect the constraints that the team encountered during their hardware-software integration phase. Nonetheless, since 64% of testers appear to endorse this prototype, it can be concluded that team 790-B's prototype was a success.

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Appendix 1

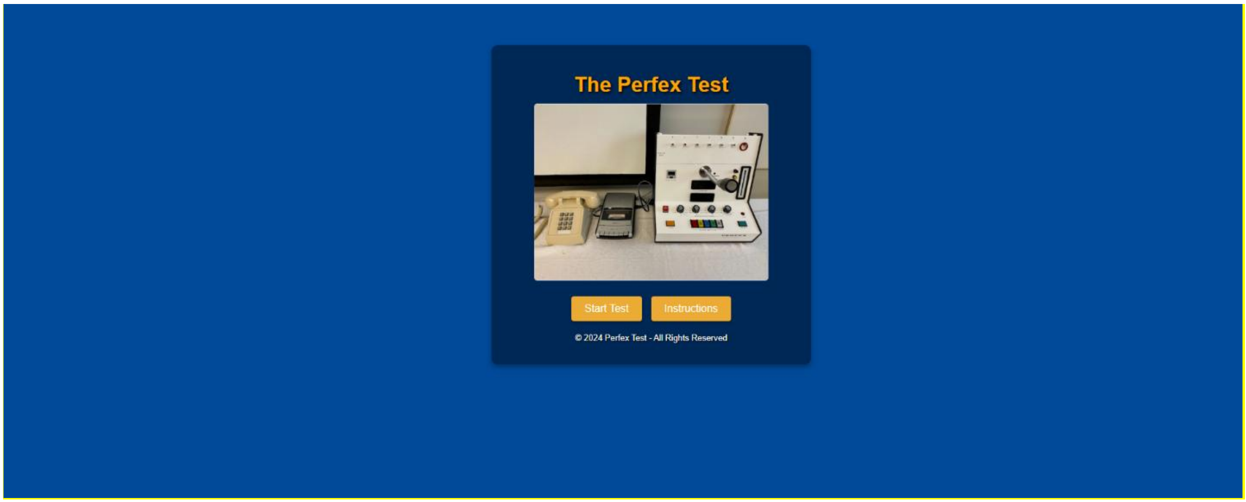

Figure 1011: The following image shows the landing page for the Perfex test which includes a button to start the test and a button to see the instructions.

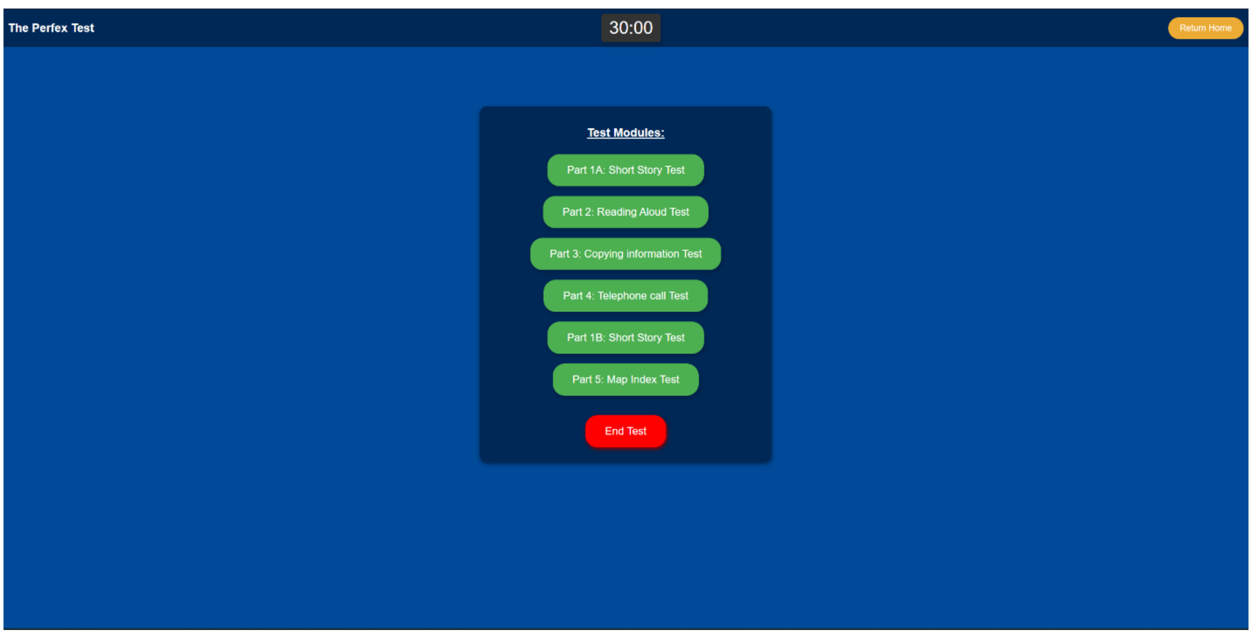

Figure 1112: The following image has the module page which shows the timer and test modules. In addition, it includes a return home button which will take you back to the main landing page for the Perfex test.

Figure 1213: The following image shows Short Story Test Part A, where the user clicks the play short story button, and then audio file is played. While listening to the short story, the user can take notes in the white box. Once the audio is done, the user must click submit notes and submit to take them to the next module. The notes will be printed out for the user to see later in part B of the Short Story Test.

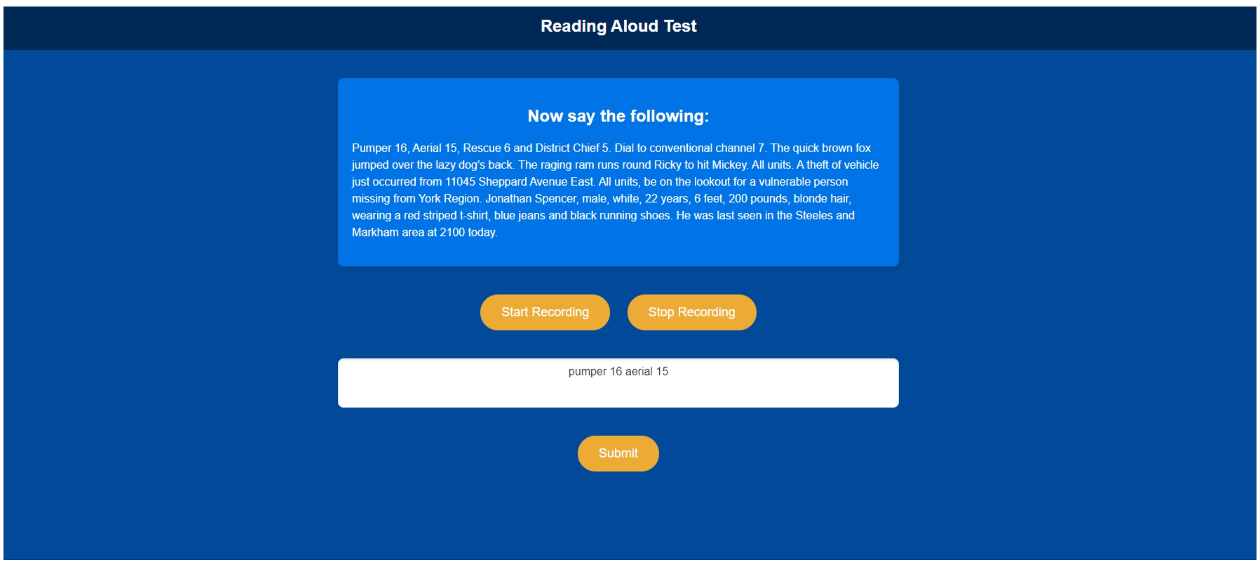

Figure 13 14: The following image shows the Reading Aloud Test, where the user clicks start recording button and must say all the words in the light blue box. Once they have said all the word, they must click stop recording button and submit the test.

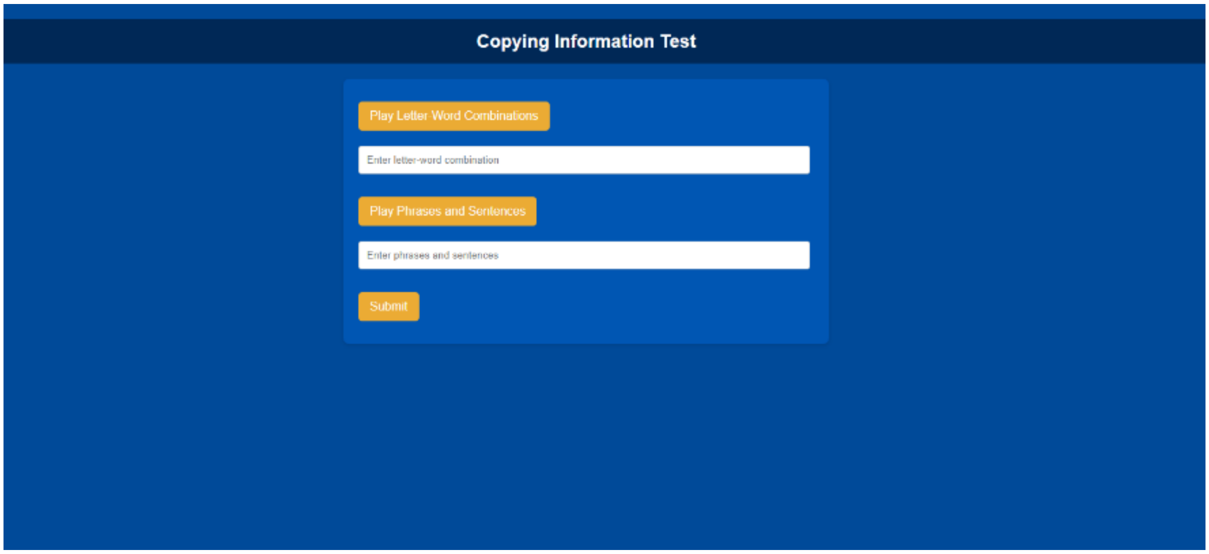

Figure 1415: The following image shows the Copying Information Test. The user must click the two play buttons to hear the audio for the letter word combinations and the phrases and sentences. When the audio plays the user must enter the information in the input box and click enter on their keyboard. Once the audio files are done, the user can not enter any more information and must submit the test.

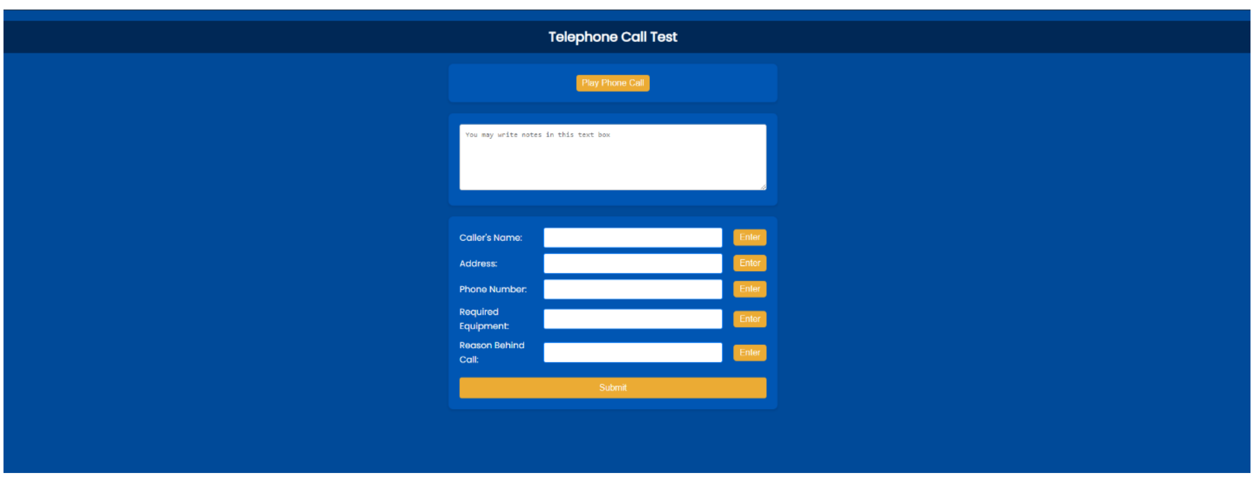

Figure 1516: The following image shows the Telephone Call Test. The user must click the Play Phone Call button to hear instructions, then later an answer phone button will pop up. While listening to the call, the user must take notes answer all required questions in the input boxes. After they have all the answers they must submit the test.

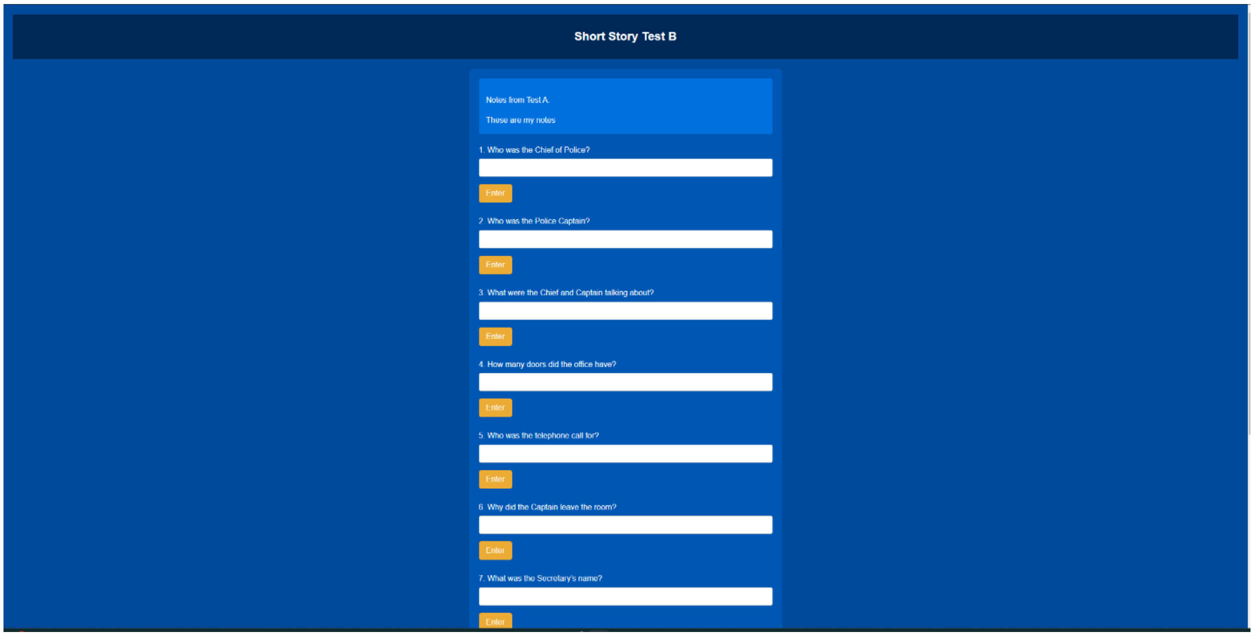

Figure 1617: The following image shows the Short Story Test Part B. With the notes the user took from Part A, they must answer the following questions about the short story. As seen in the top blue box, the notes that were taken from Part A were printed out to help the user answer the questions. The user will click submit when they are done the test.

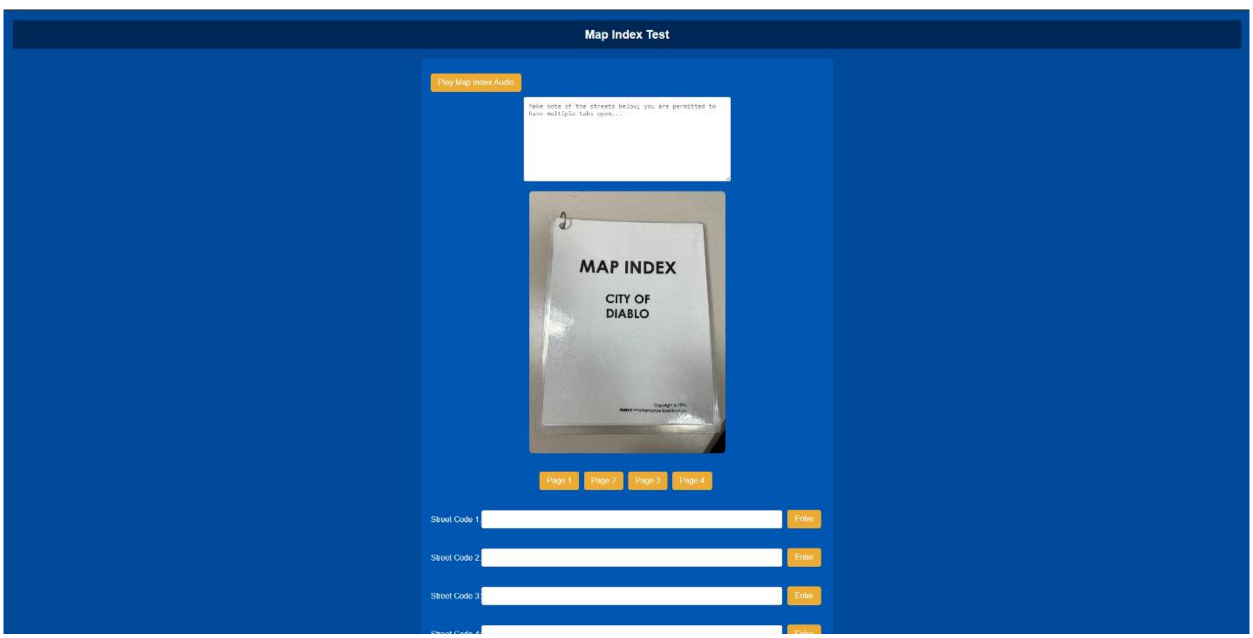

Figure 1718: The following image shows the Map Index Test. The user must click the play audio button and while it is playing, they must find all of the street codes. The street codes can be found through clicking through the various pages. In addition, the user can take note down in the white box at the top. The user will click submit once they are done the test.

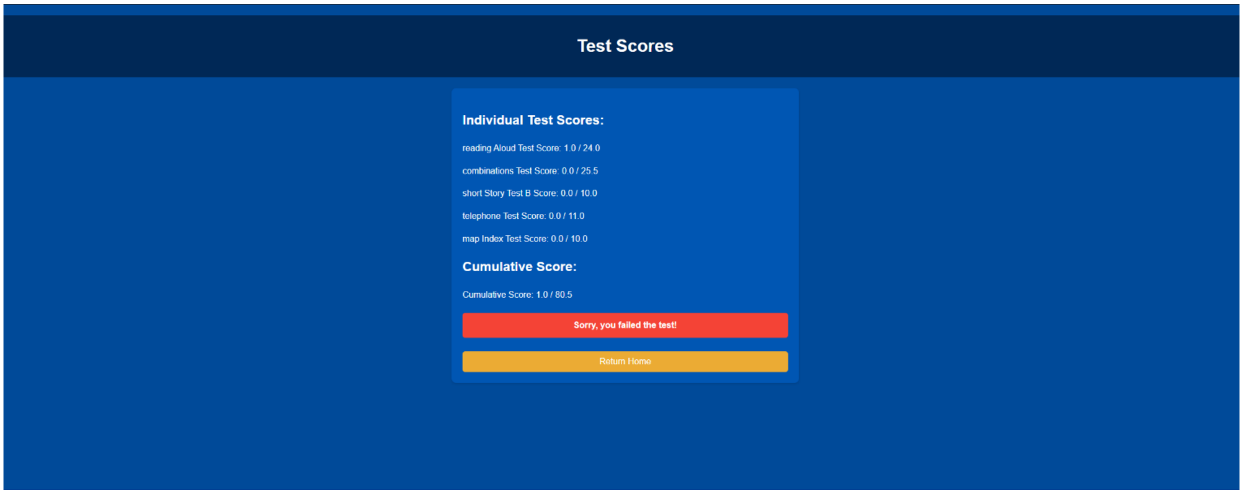

Figure 1819: The following image shows the scores from the tests. For demonstrative purposes, none of the tests were graded in this one however, as each test is completed, the score is recorded and then printed out here once the end test button is pressed. After the user is done looking at their scores, they can click the return home button to go back to the main landing page.

Table 7: Evaluation rubric that was used to evaluate team 790-B's final prototype.

	Adherence to Specifications	Appearance	Risk Mitigation Capabilities
5	Exactly like Predecessor in terms of intensity and flow. Responsive and meets all quantitative design specifications mentioned in Phase Three Report. Automated grading reflects applicant behavior correctly. The Taskbox is light and weighs no more than 0.500kg.	Visually Appealing and easy to follow. Exterior wiring is not shown. The model is extremely appealing and engaging. The model is easy to break down and modify.	No electrical hazards. No significant bugs. No issues are found between hardware and software.
4	Recognizable to its predecessor in terms of intensity and flow. 0.2-0.8 second delay response for physical modules. Quantitative specifications are applicable but slightly inaccurate. Automated grading has slight flaws. Taskbox is light and weighs no more than 0.500kg.	Most parts of the model are Visually Appealing and easy to follow. Some wires can be seen. The Model is adequately appealing and engaging. The model can be broken down and modified.	No electrical hazards. Bugs that do not significantly alter testing the device are encountered. Manageable issues are found between hardware and software (80% chance of functionality).
3	Slightly different to its predecessor in terms of intensity and flow. 0.2-0.8 second delay response for physical modules. Quantitative specifications are applicable but inaccurate. Automated grading has notable flaws. Taskbox is somewhat light and weighs more than 0.500kg.	The model has Reasonable Visual Appeal. Some wires can be seen. The model is reasonably appealing and engaging. Model can be broken down and modified, but instructions are required.	No electrical hazards. Fixable bugs that may affect Perfex's performance are encountered. Hardware and Software are somewhat compatible (50% chance of functionality).
2	Very different to its predecessor in terms of intensity and flow. 1-5 second delay response for physical modules. Quantitative specifications are not applicable. Automated grading does not reflect applicant behavior correctly. Taskbox weighs more than 0.500kg substantially.	Only some parts of the model are Visually Appealing and easy to follow. The model is either reasonably appealing or engaging/ The model can be broken down but will require intensive and careful instruction.	Prototype poses some electrical hazards. Unrecognizable bugs that affect Perfex's performance are encountered. Hardware and Software are compatible (25-50% chance of functionality)
1	Prototype fails to function. 5-10 second delay response for physical modules are encountered. Quantitative specifications are not applicable. Automated grading does not reflect applicant behavior at all. Taskbox weighs more than 0.500kg substantially.	The prototype is not Appealing and/or easy to follow. The model is not appealing or engaging. The model cannot be broken down/can be broken down but will require intensive and careful instruction.	Prototype poses concerning electrical hazards. The program contains bugs that crashes the prototype/ Hardware and software are not compatible (no chance of functionality)

APSC 103

911 Responder Testing Device Survey | Team 790-B

Please rate the following categories by highlighting a number on a scale of 1 to 5, with 1 being the lowest and 5 being the highest. One question will require a simple yes or no response. Please be honest with your response; do not hesitate to contact a project member if you need clarification for any questions.

1. How would you rate the overall appearance of this prototype? **5 POINTS**

UNPROFESSIONAL 1 2 3 4 5 VERY APPEALING

2. How would you rate the test's overall difficulty? **5 POINTS**

EASY 1 2 3 4 5 DIFFICULT

3. How intensive/stress inducing was this test? **5 POINTS**

RELAXING 1 2 3 4 5 STRESSFUL

4. Was the test responsive and clear? **5 POINTS**

HARD TO FOLLOW 1 2 3 4 5 EASY TO MANAGE

5. Would you recommend this prototype to a professional police department?

YES / NO

Figure 1920: Survey created to gain feedback from the public about the prototype created.

Appendix 2

Table 8: Work distribution breakdown.

Task	**Description of Activity**	**Activity Duration (hours)**	**Individual Responsible for Activity**
Executive Summary	Summarized the key ideas provided in the proposal.	1.5	XXXX
1.1 Problem Definition	Revised and edited problem definition and project scope.	0.5	XXXX /XXXX
1.2 Background Information	Summarized information summary section from phase 2 and 3	1.5	XXXX/XXXX
1.3 Design Solution	Provided description of constructed prototype.	4	Julien Chagnon/XXXX
1.4 Conclusions	Summarized report information and made recommendations	1.5	Julien Chagnon/XXXX
2.1 Conceptual Design Solutions	Revised section from Phase Three report according to feedback that was provided.	1	XXXX , XXXX
2.2 Decision Making	Created an evaluation matrix that assesses all designs proposed in	1.5	XXXX , XXXX

	section 2.1. Outlined the advantages and disadvantages of the selected model.		
2.3 Implementation	Described modifications to design solution brought during construction phase, as well as their reasoning.	2	Julien Chagnon/XXXX/XXXX
2.4 Project Plan and Application of Risk Mitigation	Revised Project Plan from Phase Three report and altered the Work Breakdown Structure/Gantt Chart according to new plans. Designed a risk mitigation log that outlined all adversaries during prototype construction	2	XXXX
2.5 Financial Plan Analysis	Made a table of all the expenses for the prototype	1	XXXX/XXXX
2.6 Evaluation	Compiled data collected from surveys and tests into excel charts. Provided insight on the team's success and how the final prototype could have improved.	1.5	XXXX, XXXX
Document Formatting	Formatted document according to IEEE guidelines.	3	XXXX