

ELEC 390 – FINAL REPORT

This assessment aligns with the following course learning outcomes:

- **CLO 1:** Apply ethical frameworks and decision-making within academic and project environments and assess such decisions' impacts, fairness, and outcomes.
- **CLO 2:** Assess the social impact of engineering design and technologies, including their effects on employment, urban mobility, accessibility, and sustainability.
- **CLO 3:** Equitably interact and collaborate with multidisciplinary teams with professional group dynamics.
- **CLO 4:** Reflect on one's own and others' skills inventory and performance.
- **CLO 5:** Prepare engineering documents including project proposal, and final report
- **CLO 6:** Develop documentation for the project planning, management, progress, and evaluation of the results.
- **CLO 7:** Apply engineering design theory and methodology to the project
- **CLO 8:** Design an integrated software/hardware system to meet the requirements and specifications
- **CLO 9:** Construct and validate the constructed system to determine if it meets specifications and objectives

Overview

In addition to the Design Competition, this Final Report represents the culmination of your project and needs to present the application of theoretical knowledge to a practical problem. This report needs to detail the design process, from initial concept and planning stages to final implementation and testing. It should highlight key design decisions, technical challenges, and the solutions developed to meet the project objectives. Additionally, this document provides an analysis of the system's performance and reflects on the lessons learned throughout the project, demonstrating the integration of engineering principles in addressing real-world challenges. You will also need to analyze the social context and ethical issues presented within the design challenge and include detailed discussion of the decision made and the potential impacts. You may include sections from your project proposal or logbook if you wish, using the formative feedback you received to improve the Final Report.

Note: Although the Main-Project's Final Report is intended to be a team activity and assessment, a common grade may not be awarded to all team members in the event there is evidence to suggest that one or more team members did not contribute to the project and report to a fair and equitable degree.

Report Format

Below is a list of elements and sections that should be included in your report. Note that the general specifications and many of the sections are similar to the proposal. Please refer to the rubric at the end of this document for more information.

General Specifications

- **Font:** A Sans Serif font should be used¹ for the body of the text. Acceptable fonts include: Calibri, Aptos, Helvetica, or Open Sans². A minimum 11 pt font is required.
- 1.5x line spacing (except for the Executive Summary which by convention should be single-spaced)
- **Margins:** 1"
- **Page Numbering:** Lower case Roman numerals for pages before the report's main body and Arabic numbering after) in the footer.
- **Captioning:** caption figures below the image and caption tables above the table.
- **Narration:** Use third-person passive voice (e.g. "it", "the decision", etc.). First person/personal voice ("I", "we") is appropriate for some sections of the proposal (e.g., executive summary, footnotes).
- **Length:** Aim for ~20-25 pages for the report body (excluding appendices). Concise writing is highly valued.
- **Citations:** Ensure that all material used that isn't your own is cited, regardless of whether the information is quoted or paraphrased – this includes content that is generated via artificial intelligence. Use IEEE format for citations.³
- Do not underestimate the importance of editing. Get team members to read and edit the document thoroughly.

Cover Page

The cover page should include, at minimum the following information (in order from top to bottom):

- **Course Number and Name:** ELEC 390: Principles of Design and Development
- **Project Title:** Create a name for the title of the document that is reflective of the project and purpose of the document. For example, a title could be, "Summative Report for the Development of an Autonomous Taxi Prototype to Enhance Public Road Safety". The title will reflect the attributes of the project that your team has chosen to emphasize (e.g., public safety, efficiency, sustainability etc.)

¹ As a rule of thumb, Serif fonts (e.g., Times New Roman, Georgia), are typically used for hardcopy engineering reports and documentation. When documents are written for electronic media, however, a Sans Serif typeface is typically used for easier readability.

² This is Queen's University's official font as described here: <https://www.queensu.ca/brand-central/visual-identity/typography> and is also used for the body of this document. You can download the font from Google Fonts: <https://fonts.google.com/specimen/Open+Sans>.

³ The IEEE citation format is fairly common in the engineering community. A guide on this format of citation can be found here: <https://guides.library.queensu.ca/apsc/ieee>.

- **Assigned Team Number**
- **Names and NetIDs of Team Members**
- **Date of Submission**
- **'Prepared For: [Name of Section Leader]' Field:** Your team will have an assigned Section Leader in which this document will be prepared for. Enter the name of your section leader here.
- **There should be no page number on the cover.**

Statement of Originality

A statement of originality not to exceed one page is to immediately follow the cover page (this page should be numbered 'i'). This page should have a breakdown of each team member's contributions to the report and that this document upholds the principles of academic integrity (see: <https://www.queensu.ca/academicintegrity/>). Indicate if Generative AI was used and how (refer to the course syllabus for appropriate and inappropriate uses of Generative AI in this course). This page should be e-signed and dated by all team members, indicating that all contents reported are your own unless otherwise referenced.

Executive Summary

This is a one page maximum single-spaced⁴ overview of the proposal. In the executive summary, you will want to share all of the information your readers and important stakeholders need to know. Imagine it this way: if your high-level stakeholders were to only read your executive summary, would they have all of the information they need to succeed? If so, your summary has done its job.

Table of Contents

A table of contents which lists all major headings (described below) with page references. The table of contents itself should have a Roman numeral page number.

Introduction

The introduction section should provide the foundation for your project proposal and marks the beginning of the body (i.e., start page numbering here at '1'). It sets the stage for the reader by outlining the context, problem, and goals of your project. This section should include:

- **Background Information:** Describe the field of autonomous driving, its current state, and its significance. Discuss relevant trends, challenges, or innovations in the field. Provide context for your project (e.g., the need for autonomous taxis in urban environments).
- **Problem Statement:** Define the specific problem your project aims to address. Be concise and ensure the problem is clearly framed as a gap or need in the current state of technology.
- **Objectives:** State the primary objectives of your project, such as developing an autonomous vehicle capable of safely navigating urban environments, improving passenger safety, or enhancing efficiency.

⁴ It is common for the executive summary to be single spaced, whereas the rest of the report is 1.5 spacing.

- **Scope:** Clearly define the boundaries of your project, including what it will and will not address. Ensure this aligns with the course requirements and competition guidelines.
- **Structure of the Report:** Briefly describe how the report is organized.

System Design

This section describes, at high level, your team's approach to solving the design problem. This section includes:

- **Performance Requirements:** Reiterate the quantitative benchmarks (e.g., detection accuracy, response time) which can be directly drawn from the proposal (and modified to include teaching team feedback). Recall that a performance requirement should be specific, measurable (e.g., quantifiable via tests), achievable and relevant to the design objectives.
- **Team-Specific Design Criteria:** Outline the criteria that influenced your design decisions, such as performance, cost, safety, and ethical considerations, and provide brief commentary on whether these criteria were met by the design.
- **Functional Overview:** Summarize the overall functionality of your system and its intended behaviour.
- **System Architecture:** Provide a block diagram or system overview showing major components and their interactions (e.g., sensors, processing units, actuators)

Methodology

This section describes the methods and strategies employed by your team to solve the design problem. This section includes:

- **Technologies and Tools:** Detail the hardware (e.g., Raspberry Pi, PiCar-X, Coral Edge TPU, any additional sensors and actuators) and software stack (e.g., Python, TensorFlow, OpenCV) you used in your design.
- **Algorithms:** Briefly describe key algorithms implemented, such as object detection, lane following, obstacle avoidance, brake light activation etc. Include flowcharts or pseudocode where necessary.
- **Training:** Describe how models were trained, validated, and tested. Also discuss how datasets were used, preprocessing steps, and evaluation metrics.

Implementation

Make statements regarding how smoothly your project developed. Were project milestones as laid out in the proposal met on time? Provide commentary and reflective explanations for why things went well/poorly. This section includes:

- **System Integration:** Explain how the hardware and software components were integrated while describing any challenges encountered during integration and how they were resolved.
- **Development Timeline:** Briefly recap the timeline and how the project progressed from design to deployment.

Ethical Decision Making and Considerations

Revisit the ethical aspects of the project, specifically describing the framework by which your group operated when undertaking ethical decision making.

- **Ethical Framework and Decision Making:** Describe what ethical framework or code of conduct was used to assist in making design decisions in the project. What were the challenges of using this framework? Did you have to deviate from your framework at times? If so, provide examples and justification.
- **Results:** Provide commentary on the performance of your design decision-making with respect to the ethics framework that was decided upon by the team. How has your design prevailed in achieving your ethical standards? In what ways did your design fail? What were the trade-offs of the decisions you made that adhered to your ethical framework?

Results

This section primarily discusses the results of the design that was created and executed by your team. Specifically:

- **Performance Metrics:** Present quantitative results, such as detection accuracy, lane following success rate, or time to complete a navigation task. How do these results compare to your design criteria?
- **Qualitative Observations:** Discuss the system's behavior in real-world scenarios (e.g., handling edge cases like shadows or poor lighting).
- **Comparison to Objectives:** Reflect on how the final results align with the initial goals and expectations.
- **Competition Results:** Comment on your design's performance during the competition. Was the behaviours seen expected? What happened and why?
- **Supporting Materials:** Include graphs, tables, photos, or screenshots to illustrate results.

Discussion

This is perhaps the most important section of your report – it is where you take all of the information presented in the prior sections and contextualize it to provide meaningful insights as to the performance of the team and the design. In this section, you should include:

- **Analysis of Results:** Interpret the results, discussing successes, failures, and possible reasons for observed performance.
- **Challenges and Limitations:** Highlight significant challenges faced during the project and limitations of the final system.
- **Lessons Learned:** Discuss insights gained from the project, such as technical lessons, teamwork dynamics, or project management strategies.
- **Societal and Environmental Impacts:** A discussion on the societal and environmental impacts of not just autonomous vehicles generally, but also on the impacts of your design specifically. What are some of the insights on potential impacts of your vehicle if it went mass market? What are some the benefits and trade-offs to your platform for society and the

environment? How has this project shaped your perception regarding engineering design and its potential impacts?

Conclusions and Reflections

A summary of the report, work conducted, performance achieved, and statements regarding the success of the project. It should include:

- **Summary of Work:** Summarize the key aspects of the project: problem, methodology, results, and significance. Additionally, students are expected to address each own's skills, performance, and things to improve on in preparation for future engineering project work (including but not limited to ELEC 49X).
- **Future Work:** Suggest improvements or extensions to the project for future development.
- **Closing Remarks:** Reflect on the overall success and importance of the project.

References

Include cited references and references in the Annotated Bibliography (without the summaries). This list of referenced material should follow IEEE format.

Appendices

Include additional materials that support the report, such as hardware schematics, detailed code snippets, full experimental data or test logs, photographs etc.

Submission Instructions

- Project proposals need to be upload by one team member to the OnQ submission folder by the deadline.

Grading

- The project proposal is a group project and is worth **30%** of your ELEC 390 final grade. See grading rubric for marking expectations.

Non-Compliance Penalties

- 25% per day late (i.e. per 24-hour period).
- Submissions more than 3 days late will not be assessed.
- Up to 20% deduction for not adhering to formatting requirements.

Grading Rubric

Criteria	Excellent (4)	Proficient (3)	Satisfactory (2)	Needs Improvement (1)	Unsatisfactory (0)
Background Research [CLO6]	Demonstrates thorough and comprehensive research using a wide range of reliable sources. Shows deep understanding, relevance, and connection to the design problem. Clearly integrates key theories and concepts into the design process.	Includes sufficient research from multiple reliable sources. Demonstrates a good understanding of the design problem with relevant context and concepts but lacks minor details or depth.	Provides basic research using a few reliable sources. Shows general understanding of the design problem but lacks depth, context, or significant integration of key concepts.	Displays limited research with minimal or questionable sources. Shows superficial understanding, lacking context, and minimal or incorrect integration of relevant theories or concepts.	Lacks evidence of research or relies on unreliable sources. Shows little to no understanding of the design problem and fails to include any relevant context, theories, or concepts.
Design Criteria and Specifications [CLO 7]	Clearly defines specific, measurable, realistic, and comprehensive design criteria and specifications aligned with project goals. Justifies criteria with detailed rationale considering multiple factors.	Defines relevant and mostly specific, measurable design criteria and specifications that align with project goals. Provides a reasonable level of detail and justification, missing minor considerations.	Provides basic design criteria and specifications that align with some project goals. Criteria are somewhat specific and measurable but lack detail, justification, or consideration of all aspects.	Outlines vague or incomplete design criteria and specifications that are loosely related to project goals. Lacks specificity, measurability, and adequate justification. Misses several key considerations.	Fails to provide clear or relevant design criteria and specifications. Criteria are unclear, not measurable, or not aligned with project goals, with no supporting rationale.
Description of Design Process [CLO7]	Provides a detailed, logical, and clear description of each stage of the design process, including ideation, development, prototyping, testing, and refinement. Demonstrates critical thinking, creativity, and problem-solving.	Describes the main stages of the design process with clarity and logical flow. Includes most elements like ideation, development, testing, and refinement. Shows understanding of decisions but lacks minor details.	Offers a general description of the design process, covering some stages but missing others. Demonstrates basic understanding of the process but lacks clarity and detail in explaining decisions or iterations.	Provides an incomplete or unclear description of the design process. Covers few stages with minimal detail, lacks logical flow, and shows limited understanding of decision-making or problem-solving.	Fails to provide a coherent description of the design process. Missing key stages, lacks clarity, logical flow, and explanation of decisions or iterations. Shows little to no understanding of the process.
System Design and Integration [CLO 8]	Designs a fully integrated software/hardware system that clearly meets all project requirements and specifications. Demonstrates innovative and well-justified design choices with thorough documentation of integration processes.	Designs an integrated software/hardware system that meets most project requirements and specifications. Design choices are justified, but documentation of integration processes may lack detail or innovation.	Designs a partially integrated system that meets some project requirements and specifications. Design choices are somewhat justified, but key aspects of integration may be unclear or missing.	Provides a minimally integrated system with limited connection between software and hardware. Design choices are vague, and documentation of integration processes is incomplete or lacks clarity.	Fails to design an integrated software/hardware system. Does not meet project requirements or specifications. Design choices are unclear, unjustified, or undocumented.

System Validation and Testing [CLO 9]	Conducts comprehensive validation and testing of the constructed system, demonstrating how it meets all specifications and objectives. Includes clear metrics, results, and critical analysis of limitations and performance.	Conducts validation and testing of the system with clear metrics and results that address most specifications and objectives. Some limitations or performance issues may lack detailed analysis.	Provides basic validation and testing of the system, addressing some specifications and objectives. Metrics or results may lack detail or clarity, and critical analysis of limitations is minimal.	Performs minimal validation and testing of the system. Metrics, results, or analysis are incomplete or unclear. Does not adequately address how the system meets specifications or objectives.	Fails to validate or test the system. Provides no evidence of performance against specifications or objectives. Metrics, results, or critical analysis are absent or irrelevant.
Teaming (Team Style, Equity, Conflict Resolution, Leadership) [CLO 3]	Demonstrates an inclusive and collaborative team style that effectively engages all members, promotes equity, and values diverse perspectives. Successfully identifies and resolves conflicts through constructive dialogue. Shows strong leadership by clearly delegating tasks, fostering team cohesion, and motivating members to achieve shared goals.	Displays a collaborative team style that engages most members and promotes fairness. Resolves conflicts effectively, with minor issues. Shows leadership by delegating tasks and maintaining team cohesion but may lack in some areas.	Demonstrates a generally positive team style with some attempts at inclusion. Resolves conflicts with moderate success but may avoid or inadequately address certain issues. Displays basic leadership but lacks consistency.	Shows a limited or inconsistent team style with minimal attempts at equity and inclusion. Has difficulty resolving conflicts, often relying on external intervention. Displays weak leadership with unclear delegation of tasks.	Fails to demonstrate effective team collaboration. Lacks equity, often excluding members or perspectives. Unable to resolve conflicts constructively and shows little to no leadership or coordination within the team.
Identification of Ethical Frameworks and Examples [CLO 1]	Clearly identifies multiple relevant ethical frameworks and thoroughly explains their application to the design. Provides specific, well-chosen examples where each framework would apply, demonstrating deep understanding of ethical considerations.	Identifies relevant ethical frameworks and explains their application to the design with clarity. Provides several examples, but some lack depth or direct relevance to the design context.	Identifies at least one ethical framework but provides a basic or limited explanation of its application. Includes examples, but they may be general or lack clear relevance to the specific design context.	Mentions an ethical framework with minimal explanation or unclear connection to the design. Provides few or vague examples, showing limited understanding of the ethical considerations.	Fails to identify relevant ethical frameworks or provide examples. Shows little to no understanding of the ethical considerations relevant to the design process.
Social Impact Analysis [CLO 2]	Provides a thorough and insightful analysis of the social impact of the project, including its effects on employment, urban mobility, accessibility, and sustainability. Explores multiple perspectives and integrates them into a cohesive discussion.	Explores the social impact of the project with good detail, covering most aspects such as employment, mobility, accessibility, and sustainability. Some areas may lack depth or integration across perspectives.	Provides a basic analysis of social impact, addressing some aspects such as employment, mobility, or sustainability but with limited depth or integration. Misses key perspectives or fails to fully connect to the project.	Mentions the social impact of the project but with minimal or unclear connections to topics such as mobility, accessibility, or sustainability. Analysis is shallow and lacks clear examples or integration.	Fails to address the social impact of the project or provides unrelated or vague statements. Shows little to no understanding of how the project affects society, sustainability, or accessibility.
Reflection on Skills [CLO 4]	Thoughtfully reflects on individual and team skills, clearly identifying strengths and weaknesses. Includes specific examples of skill applications, growth, and areas for improvement, with strategies to address identified gaps.	Reflects on individual and team skills, identifying strengths and weaknesses. Includes examples of skill applications and mentions areas for improvement, though strategies for growth may lack detail.	Provides a general reflection on skills with some discussion of strengths and weaknesses but lacks detail or depth. Examples are vague or not clearly connected to project activities.	Provides a minimal or surface-level reflection on skills, with limited mention of strengths, weaknesses, or strategies for improvement. Examples are absent or not relevant to the project.	Fails to reflect on individual or team skills. Lacks any mention of strengths, weaknesses, or examples of skill application. No strategies for improvement are provided.

Project Documentation [CLO 6]	Provides comprehensive documentation that clearly articulates all project components: objectives, problem statement, stakeholder needs, information analysis, and project planning. Each component is detailed, logically organized, and demonstrates a thorough understanding of the project's scope and goals.	Offers well-organized documentation that covers most project components with clarity: objectives, problem statement, stakeholder needs, information analysis, and project planning. Some elements may lack minor details or depth.	Provides basic documentation that includes some project components (e.g., objectives, problem statement, stakeholder needs) but lacks detail, depth, or clarity in presenting information analysis and planning.	Presents incomplete or unclear documentation with minimal details on several project components. Lacks logical organization and demonstrates limited understanding of the project's scope and goals.	Fails to provide coherent documentation. Lacks most project components, such as objectives, problem statement, stakeholder needs, information analysis, or planning. Shows little to no understanding of the project.
Writing (Organization) [CLO5]	Writing is clearly organized into logical paragraphs and sections including smooth transitions and clear links between sections.	Writing is clearly organized into paragraphs and sections, including transitions.	Writing is structured into paragraphs and sections, including transitions.	Writing is mostly organized at the document-level, however loosely organized at the sentence level.	Disordered document-level organization and loose sentence-level organization.
Writing (Reasoning) [CLO5]	Statements are well supported by evidence synthesized from quality analysis and consider how limitations and uncertainties affect conclusions.	Statements are supported with relevant evidence, including discussion of limitations and uncertainties.	Statements are supported with evidence, limitations and uncertainties are mentioned.	Statements are supported by evidence of varying quality. Limitations and uncertainties may not be included.	Message is presented, however not entirely supported.
Writing (Graphics) [CLO5]	Graphical elements are all carefully designed and support the main purpose.	Graphical elements are used to support the main purpose.	Graphical elements used appropriately but not consistently referenced in text and/or do not directly relate to purpose.	Some graphical elements not discussed and/or do not contribute to the report.	Graphical elements not understandable, not related to text.