A3 No. and Name
Group 2: **V-Track**

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Stakeholders (role & department)	
1	AI & ML Coordinator, Conestoga College
2	Other Conestoga College stakeholder(s)
3	Government
4	Administrative & Policy Stakeholders

Company objective
Canada Government

Start date & planned duration
2025-05-13
14 weeks

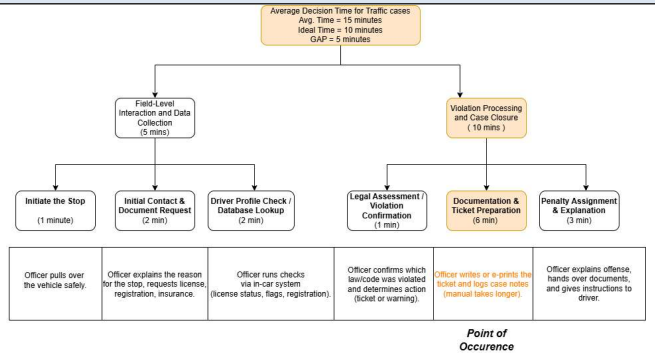
1. Clarify the problem

Current Situation
Traffic violation penalties are assessed manually, taking an average of **15 minutes** per case. Officers rely on spreadsheets and disconnected databases, making it hard to access full driving histories. This leads to inconsistent penalties and delays in decision-making.

Ideal Situation
An AI-powered Decision Support System would reduce decision time to **10 minutes**, integrating driver history, offense context, and risk factors. It would ensure fair, consistent penalties and improve efficiency across jurisdictions.

Gap
There is a **5-minute** time gap per case between manual and AI-based assessment. The current system lacks data integration and standardization, while the ideal setup enables fast, data-driven decisions with unified driver profiles.

2. Breakdown the problem



3. Set the Target

Reduce the average decision time for traffic offense penalty assignment from **15 minutes to 10 minutes** by the end of 2025, by standardizing the evaluation process and ensuring consistency in fairness and speed.

4. Analyse the Root Cause

Why does the process take too long at Documentation & Ticket Preparation?
→ Because officers manually write or e-print the ticket and log case notes, which is time-consuming.

Why is manual writing or e-printing so time-consuming?
→ Because there is no integrated or automated system to auto-fill or generate tickets and notes.

Why isn't there an integrated system for ticket generation?
→ Because current systems are outdated or lack real-time synchronization with driver databases and violations.

Why are systems outdated and not synchronized?
→ Because budget constraints and limited digital infrastructure have prevented modernization.

Why hasn't the budget been allocated to modernize this process?
→ Because of low awareness of how AI-driven automation can reduce case handling time and improve decision-making.

5. Develop Countermeasures

	Criteria >	Time Efficiency	Consistency	Implementation	Scalability	Integration	Legal Compliance	Overall Score (/100)	Ranking	Potential Problems
	Weight (/100)	25	25	15	10	10	15			
	Min Score (/10)	8	8	6	6	6	8			
1	AI Automated Enforcement Cameras	10	10	4	6	6	6	77	3	Below the minimum desired score for: Cost of Implementation; Legal Compliance High setup cost; legal limits on where AI enforcement is permitted in Ontario.
2	Electronic Ticketing (e-Citation)	10	6	6	8	8	9	80	2	Below the minimum desired score for: Fairness & Consistency Standardizes ticketing but does not eliminate profiling in who gets stopped.
3	Policy Reform - End Minor Stops	8	10	10	9	10	6	89	1	Below the minimum desired score for: Legal Compliance Requires legislative support; may face resistance from police unions or legal barriers.
4	Status Quo + Officer Training	2	4	10	10	9	10	65	5	Below the minimum desired score for: Time Efficiency; Fairness & Consistency Training alone shows minimal impact on bias or time. No systemic change.
5	RAG-Based Judicial Retrieval System	8	6	5	7	6	7	66	4	Below the minimum desired score for: Fairness & Consistency; Cost of Implementation Bias risk in outputs; initial development and integration are costly and complex.

7. Monitor Results & Process

8. Standardise & Share Success

1. GitHub Link: shantanudxt/CSCN8040-VTrack
2. Dataset: Stop Data - Catalog

Abstract

Traffic enforcement remains a time-intensive and inconsistent process in many jurisdictions, with stop durations often exceeding 15 minutes due to fragmented data systems, manual documentation, and limited access to historical driver information. This study introduces V-Track, an AI-driven decision support system designed to streamline the processing of traffic violations—particularly speeding—by integrating Retrieval-Augmented Generation (RAG) technology with driver profiles and judicial data.

Using a cleaned and adapted dataset from Washington, D.C. Metropolitan Police Department (MPD), consisting of over 40,000 records filtered for “Observed Moving Violations,” this research conducts exploratory data analysis and hypothesis testing to evaluate enforcement inefficiencies. Statistical results reveal significant variability in stop durations across stop types and districts, with a median processing time of 10 minutes. The Shapiro-Wilk test confirmed non-normality of duration data, validating the use of non-parametric tests such as Kruskal-Wallis and Wilcoxon Signed-Rank to assess RAG’s impact.

V-Track aims to reduce processing time below 10 minutes, automate penalty recommendations, and ensure fairness and legal compliance. Although the data is simulated for Ontario conditions, the proposed system offers a scalable model for modernizing traffic enforcement through AI, improving operational efficiency, consistency, and public trust in the justice process.

Introduction

Traffic enforcement in Ontario faces inefficiencies due to manual workflows and fragmented data systems, resulting in an average stop processing time exceeding 15 minutes. These delays contribute to inconsistent penalty assignments and erode public trust in enforcement fairness. Officers currently rely on disconnected spreadsheets and databases, limiting access to comprehensive driver histories and hindering data-driven decisions. This research introduces V-Track, an AI-driven system integrating driver profiles, judicial data, and risk factors using RAG technology. The system seeks to reduce enforcement time, standardize penalties, and improve operational consistency, addressing a critical gap in current practices.

Problem Statement

Manual management of traffic violation penalties in Ontario requires approximately 15 minutes per case, with officers consulting multiple unlinked systems and incomplete records. This leads to delays and inconsistent penalty outcomes, creating a measurable inefficiency gap. The lack of an automated, real-time system for accessing driver information and generating penalty recommendations underscores the need for an integrated solution to enhance speed, fairness, and accuracy in enforcement processes.

Targets

The primary goal is to reduce the average traffic stop processing time from 15 minutes to below 10 minutes by the end of 2025, aligning with the observed median of 10 minutes in the MPD dataset. Secondary objectives include automating ticket documentation, standardizing evaluation procedures to reduce penalty variance to less than 5% among similar cases, and maintaining data consistency above 96%. Progress will be monitored through audits, fairness assessments, and system performance diagnostics.

Root Cause Analysis

Analysis reveals that ticket documentation and preparation consume approximately 6 minutes per case (40% of total time), driven by manual writing and note logging due to the absence of an integrated system. Legacy enforcement systems lack real-time synchronization with driver databases, hindered by outdated technology and limited digital infrastructure. Budget constraints and underappreciation of AI benefits have delayed modernization, collectively causing inefficiencies and inconsistencies in traffic enforcement.

Objectives

This research aims to develop and evaluate V-Track, an AI decision support system providing real-time integration of driver histories and automated penalty assignments. Effectiveness will be assessed using statistical analysis of adapted MPD traffic stop data, aligned with Ontario's legal framework. Additional goals include ensuring fairness, legal compliance, and operational efficiency, with quantitative methods recommending scalable, data-driven solutions for enforcement modernization.

Methodology

The methodology integrates exploratory data analysis (EDA), statistical hypothesis testing, and structured problem assessment. We utilized a dataset from the MPD (https://catalog.data.gov/dataset/stop-data-b6fdf), containing 105,376 records of vehicle, pedestrian, bicycle, and harbor stops from January 2023 to June 2024. Fields include stop duration, violation type, driver demographics, officer notes, penalties, date, time, and location. A filtered sample of 40,590 records (post-cleaning) was adapted to simulate Ontario conditions through data transformations.

EDA: Characterized stop durations (mean 8.9 minutes, median 10 minutes) and penalty patterns, revealing a right-skewed distribution. Visualizations (histograms, box plots) highlighted variability by STOP_TYPE and STOP_DISTRICT.
Normality Test: The Shapiro-Wilk test (statistic 0.3358, $p < 0.0001$) rejected normality, supporting non-parametric methods.
Statistical Tests: Kruskal-Wallis tests confirmed significant effects of STOP_TYPE, STOP_DISTRICT, and specific TICKET_/WARNING_ types on STOP_DURATION. Wilcoxon Signed-Rank Test is planned for future paired data to assess RAG impact against the 10-minute benchmark.
Limitations
The study relies on simulated data adapted from a U.S.-based MPD dataset, which may not fully reflect Ontario's enforcement nuances. Mapping violation codes and penalties across jurisdictions introduces assumptions affecting accuracy. The analysis excludes variables like officer discretion or local policy variations, focusing on processing time and penalty consistency without addressing broader social or legal impacts. These limitations should inform result interpretation.

Expected Impact

Successful implementation of V-Track could reduce traffic stop processing times, enhancing efficiency and allowing officers to focus on public safety. Standardizing penalties and improving driver history access may increase fairness and transparency, boosting public trust. Streamlined workflows could lower costs and improve service quality, supporting justice modernization and AI-driven public sector transformation.

Future Work

Future research will expand the dataset to include diverse enforcement scenarios and conduct real-world pilot testing with Ontario agencies. Development will focus on integrating judicial databases, refining AI models for nuanced penalties, and designing user-friendly interfaces. Studies will also explore social and legal implications to ensure ethical, equitable outcomes.

References

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