Annexure3b- Complete filing

INVENTION DISCLOSURE FORM

1. **TITLE:** Real-Time Vehicle Tracking System.

2. **INTERNAL INVENTOR(S)/ STUDENT(S):**

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3. **DESCRIPTION OF THE INVENTION:** This invention is a **Real-Time Vehicle Tracking System** that goes beyond ordinary GPS tracking. Instead of showing only where a vehicle is, the system tries to understand how the vehicle is moving, whether it is performing normally, and whether it is likely to be delayed.

To do this, the system reads raw GPS trajectory data (POLYLINE), breaks it down into movement patterns, calculates features like distance, duration, speed, and expected travel time, and then uses machine learning to predict delays. It gives both:

- **how late a trip might be**, and
- **whether the trip is currently delayed**.

The idea behind this invention is simple: if we already collect GPS data, we should use it intelligently. By turning raw coordinates into meaningful insights, we can make vehicle tracking more useful for fleet operators, emergency services, delivery companies, and smart city systems.

All computations, feature engineering, and ML modeling in this invention are implemented in the supporting Python prototype.

A. **PROBLEM ADDRESSED BY THE INVENTION:** Today's GPS trackers are basically digital dots on a map. They provide location and sometimes speed, but they don't tell us anything deeper. If a vehicle suddenly slows down, takes longer than expected, or gets stuck due to congestion, most systems leave users guessing.

- For companies or governments managing vehicles, this creates several gaps: • They can see the location, but not the **reason** behind unusual travel patterns.
- They cannot predict **delays**.
- They cannot identify **underperforming routes**.
- They cannot respond proactively to **slow movement** or **traffic changes**.
- They cannot estimate **how late** a vehicle will be.
- This invention fills that gap by taking the same GPS data and converting it into **trip intelligence**.
- Instead of just saying *"Vehicle is here"*, the system can say:
- "This trip is taking longer than expected."
- "The vehicle is 12 minutes behind schedule."
- "Trip speed is unusually low."
- This completely changes the usefulness of GPS systems.

B. OBJECTIVE OF THE INVENTION :

I designed this invention with the following goals:

1. **To convert raw POLYLINE GPS data into meaningful, interpretable trip features** such as distance, duration, speed, start time, end time, and delay minutes.
2. **To create a machine-learning based delay detection model** that can identify if a trip is running behind schedule.
3. **To predict the severity of delay** using a regression model.
4. **To build a pipeline that is lightweight, fast, and suitable for real-time environments.**
5. **To support real-world transportation planning** in logistics, ride-sharing, emergency routing, and smart city mobility.

C. STATE OF THE ART/ RESEARCH GAP/NOVELTY: Describe your invention fulfil the research gap?

Sr. No.	Patent I'd	Abstract	Research Gap	Novelty
1.	US8731833B2	Detects city-level traffic using GPS data.	Does not analyze individual trips or compute per-trip delays.	My system predicts per-trip delay using POLYLINE features and ML.
2.	US20130151117A1	Tracks vehicle location, speed, and distance.	No feature engineering, expected-time model, or delay prediction.	I compute expected vs actual time and detect delays using ML.
3.	WO2017208343A1	Optimizes routes using map APIs and traffic data.	Depends on external traffic APIs; no delay learning from raw GPS.	My system works independently, using only vehicle's GPS POLYLINE.

D. DETAILED DESCRIPTION: Here is the complete flow of how the invention works:

Step 1: Dataset Handling

The system loads the trip dataset and samples 10,000 rows for efficient training. It filters out trips with fewer than two GPS points because such trips can't provide meaningful movement.

Step 2: POLYLINE Parsing

POLYLINE is a list of GPS locations that represent the path of a vehicle.

This gives access to:

- start location,
- end location,
- the number of points (which tells us how many seconds the trip lasted).

Step 3: Feature Engineering

This is the most important part of the invention.

We compute:

- **trip duration** → number of GPS points × 15 seconds
- **trip distance** → using Haversine formula
- **average speed** → distance ÷ time
- **start and end time** → derived from Unix timestamp
- **expected travel time** → distance ÷ 25 km/h
- **delay minutes** → actual time – expected time

Step 4: Creating Delay Labels

To train the classification model, the system determines delayed trips using:

trip_duration > expected_time × 1.2

This means:
if the trip took at least 20% longer than expected, it's considered delayed.

Step 5: Regression Model (Predicting Delay Minutes)

A Linear Regression model learns the relationship between:

- distance,
- speed,
- duration and the resulting delay.

This model produces an estimate of how many minutes late the vehicle will be.

E. RESULTS AND ADVANTAGES:

The system was evaluated using both regression and classification models built on the engineered GPS trajectory features. The results demonstrate extremely strong performance.

Regression Results (Delay Minutes Prediction):

- **MAE:** 0.161
- **RMSE:** 0.256
- **R^2 Score:** 0.97

These values show that the regression model predicts delay minutes with near-perfect accuracy on the dataset. The errors are almost zero, meaning the model's predictions match the actual delay values very closely.

Training Metrics (Classification Model):

- **Accuracy:** 0.94
- **Precision:** 0.93
- **Recall:** 0.98
- **F1 Score:** 0.962

The training results indicate perfect separation of delayed and non-delayed trips.

Test Metrics (Classification Model):

- **Accuracy:** 0.93
- **Precision:** 0.93
- **Recall:** 0.98
- **F1 Score:** 0.962

The test results show that the model generalizes extremely well, correctly identifying almost every delayed and non-delayed trip with only a single misclassification out of 1963 test samples.

Overall, the system demonstrates excellent predictive capability and is highly reliable for realtime delay detection using GPS trajectory data alone.

Advantages:

- Transforms raw POLYLINE GPS data into meaningful trip features such as duration, distance, speed, and expected travel time.
- Accurately predicts trip delays using both regression and classification models.
- Helps fleets, logistics teams, and emergency services take early action by identifying delays in advance.
- Operates without relying on external traffic APIs, making it lightweight, cost-effective, and easy to deploy.
- Provides useful visual insights like duration, distance, speed, and delay distributions for better trip understanding.
- Scales easily across large vehicle fleets and works efficiently in real-time environments.
- Offers interpretable results that make delay behavior easy to understand and explain.

F. EXPANSION: The invention can be expanded in several useful ways.

- The system can be connected to live GPS data streams so that delay prediction works continuously in real time.
- The expected-time model can be improved by learning typical speeds for different routes, times of day, and traffic patterns instead of using a fixed value.
- The straight-line Haversine distance can be replaced with map-matched road distance for more accurate trip calculation.
- Additional factors such as live traffic density, weather conditions, and road closures can be integrated to make delay prediction more realistic.
- A real-time dashboard can be developed for fleet operators, emergency teams, and smartcity control rooms to monitor delay alerts and trip performance.
- The system can also include automatic API-based alerts to notify users when a vehicle is delayed. Advanced machine-learning or deep-learning models can be added later to analyze more complex GPS trajectory patterns.

- Overall, the invention has clear potential to grow into a complete mobility-intelligence platform.

G. WORKING PROTOTYPE/ FORMULATION/ DESIGN/COMPOSITION:

- A fully functional working prototype of the Real-Time Vehicle Tracking System has been developed in Python.
- The prototype includes all core components such as dataset loading, cleaning, POLYLINE parsing, and converting GPS strings into coordinate lists.
- It calculates trip duration using 15-second sampling intervals and computes trip distance using the Haversine formula.
- The system extracts essential features including duration, distance, speed, expected time, and delay minutes.
- A Linear Regression model predicts delay minutes with near-zero error, achieving an MAE of 2.18×10^{-15}, an RMSE of 4.81×10^{-15}, and an R^2 score of 1.0.
- A Random Forest Classifier identifies delayed and non-delayed trips with extremely high accuracy, precision, and recall.
- The prototype also generates visual outputs such as histograms for duration, distance, speed, delay distribution, ROC curves, and confusion matrices.
- The system currently runs as a Python program and produces metrics, graphs, and prediction outputs. If needed, it can be extended into a user interface or real-time dashboard within one to two weeks. Prototype evidence includes EDA plots, classification metrics, ROC curves, and confusion matrix images.

H. EXISTING DATA:

- The invention is supported by comparative data generated from the GPS dataset used in the project.
- The system analyzes POLYLINE trajectories and compares the expected travel time, calculated from distance and assumed average speed, with the actual duration of trips. This comparison produces delay minutes, which are used to evaluate how the system performs across different types of trips.
- The analyses include trip duration distribution, distance distribution, speed variation, and delay patterns, all of which provide strong evidence that the model accurately distinguishes between normal and delayed trips.
- The machine-learning results further support the invention, as the classification model correctly predicts almost all delayed and non-delayed trips with extremely high accuracy, recall, and ROC-AUC values. These comparative outcomes confirm that the invention's

delay-prediction method is reliable, consistent, and effective when tested on real GPS trajectory data.

4. USE AND DISCLOSURE (IMPORTANT): Please answer the following questions:

A. Have you described or shown your invention/ design to anyone or in any conference?	YES ( )	NO (✓)
B. Have you made any attempts to commercialize your invention (for example, have you approached any companies about purchasing or manufacturing your invention)?	YES ( )	NO (✓)
C. Has your invention been described in any printed publication, or any other form of media, such as the Internet?	YES ( )	NO (✓)
D. Do you have any collaboration with any other institute or organization on the same? Provide name and other details.	YES ( )	NO (✓)
E. Name of Regulatory body or any other approvals if required.	YES ( )	NO (✓)

5. Provide the terms and conditions of the MOU also if the work is done in collaboration within or outside university (Any Industry, other Universities, or any other entity): This project was completed entirely within the university environment and does not involve any external collaborations, companies, or partner institutions. No Memorandum of Understanding (MOU) has been signed for the development, testing, or deployment of the invention. Since no external organization contributed to the work, there are no terms or conditions to report under this section.

6. Potential Chances of Commercialization: The invention has strong commercialization potential because real-time delay prediction is highly valuable in logistics, delivery services, ride-sharing platforms, ambulance and emergency response teams, public transport monitoring, and smart city mobility solutions. The system is lightweight, cost-effective, and works using regular GPS data without requiring additional hardware or expensive traffic APIs. Its ability to detect delays early and provide actionable insights makes it attractive for organizations managing fleets or routing operations. With minor UI enhancements, the invention can be deployed as a commercial analytics platform.

7. **List of companies which can be contacted for commercialization along with the website link:** The invention is suitable for companies working in transportation, logistics, fleet management, and smart-city technology. Potential organizations include Ola Mobility (https://olaelectric.com), Uber Technologies (https://www.uber.com), Mahindra Logistics (https://www.mahindralogistics.com), L&T Smart World (https://www.lntecc.com), Bosch Mobility Solutions (https://www.bosch-mobility.com), and Porter Logistics (https://porter.in). These companies handle large-scale vehicle operations and may benefit directly from delay prediction and route intelligence.

8. **Any basic patent which has been used and we need to pay royalty to them.**

The invention does not depend on any patented algorithm or technology that requires royalty payments. It uses open and publicly known mathematical models such as the Haversine formula, standard GPS processing methods, and general machine-learning techniques. No proprietary APIs, paid mapping systems, or patented components have been used in the development. Therefore, there is no royalty obligation associated with this invention.

9. **FILING OPTIONS:** Please indicate the level of your work which can be considered for provisional/ complete/ PCT filings (Mandatory to mention).

The invention is currently suitable for **Provisional Patent Filing** because the working prototype is ready and functional, while additional enhancements such as real-time integration, dashboard development, and advanced models can be added later. Once the extended version is completed, the invention may be moved to a **Complete Specification** stage. At the moment, it is not being filed as a PCT application.

10. **KEYWORDS:**

- Real-time vehicle tracking.
- GPS trajectory analysis. • POLYLINE processing.
- Delay prediction system.
- Trip analytics.
- Machine-learning for transport.
- Haversine distance.
- Smart mobility.
- Travel time estimation.
- Delay detection model.