Zero Crashes Initiative

Location: Austin, Texas

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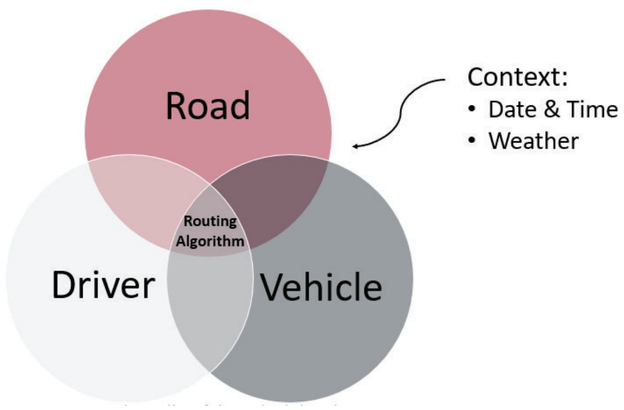
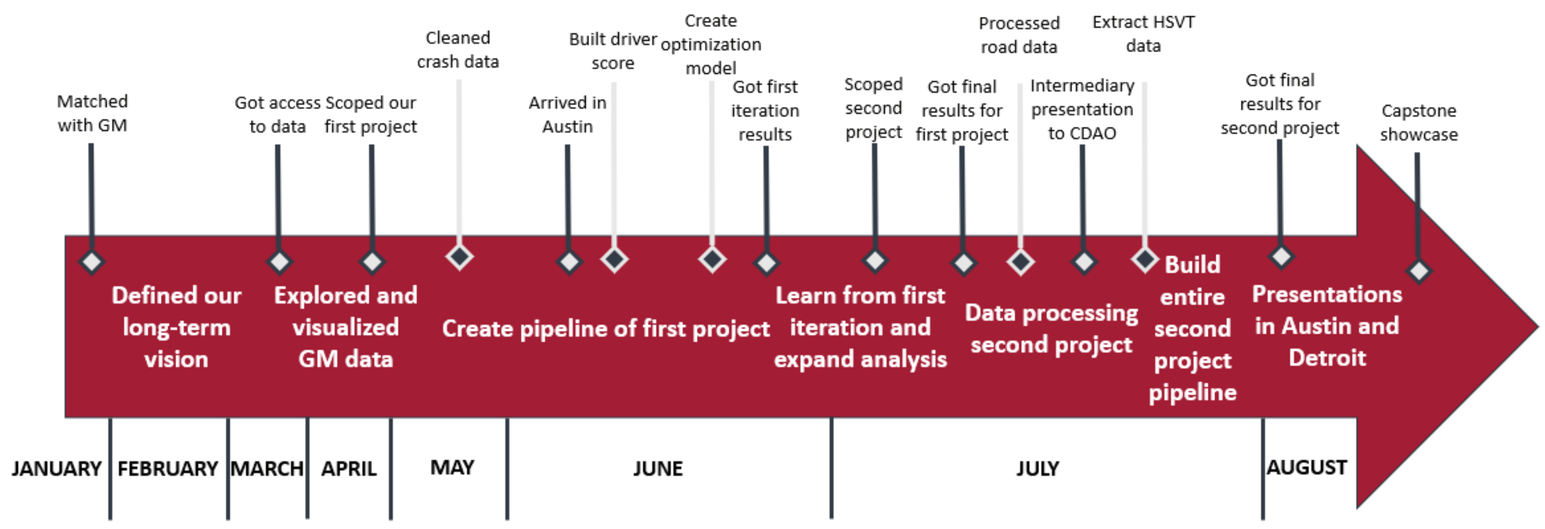
1. Overview

Road safety is a function of three components: **driver, vehicle and road**, on top of which the **context of the trip** plays an important role.



2. Timeline



3. First product goal

To explain crashes, our first goal is to understand how a given vehicle or behavior feature impacts safety. Therefore, we built a **reproducible framework that quantifies the real effect of any feature on safety**, which relies on three main data sources:

Data type	Size
Vehicle data	5.2M
Trip characteristics data	8.3B
Severe crashes data	37K

We have identified and rigorously removed three biases: the **vehicle characteristics**, the **driving time** and the **driving behavior**.

4. Driver score method comparison

To tackle the **driving behavior** bias, we built a **driver score**, derived from predicted crash likelihood. Below are the testing AUC for combinations of resampling and modeling techniques:

	Re-sampling techniques		
Modeling	**Over-sampling**	**SMOTE[1]**	**SMOTEEN[2]**
Logistic Regression	0.727	0.730	0.722
FFNN (Neural Network)	0.752	0.722	0.723
CART	0.699	0.689	0.667
Random Forest	0.782	0.738	0.688

1 = Synthetic minority over-sampling technique
2 = Combine over- and under-sampling using SMOTE and edited nearest neighbours

5. Bias removal techniques

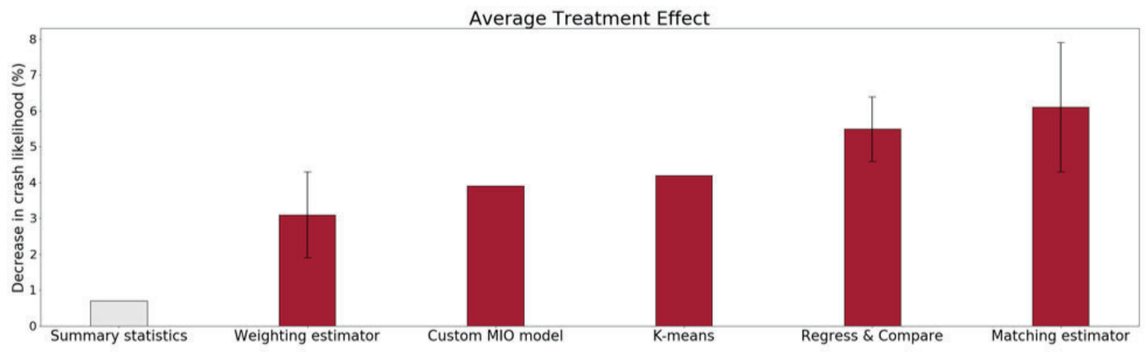
In order to analyze the **unbiased effect of a given feature on safety**, we create groups of **similar drivers** and compare treated and untreated drivers in each group, using the following techniques:

- **K-Means clustering** to gather similar drivers together,
- **Causal inference estimates** to simulate a randomized experiment,
- A custom **mixed-integer optimization** model:

$$\min_{\text{driver assignment to groups}} \sum_{\text{categorical features}} \sum_{\text{groups}} \text{proportion discrepancies between treated and untreated drivers}$$

6. Results & impact

We applied our framework to uncover the real effect of the **forward collision alert** safety option. **Customers, GM and insurance companies**, which can better adapt safety option pricing, can benefit from such findings.



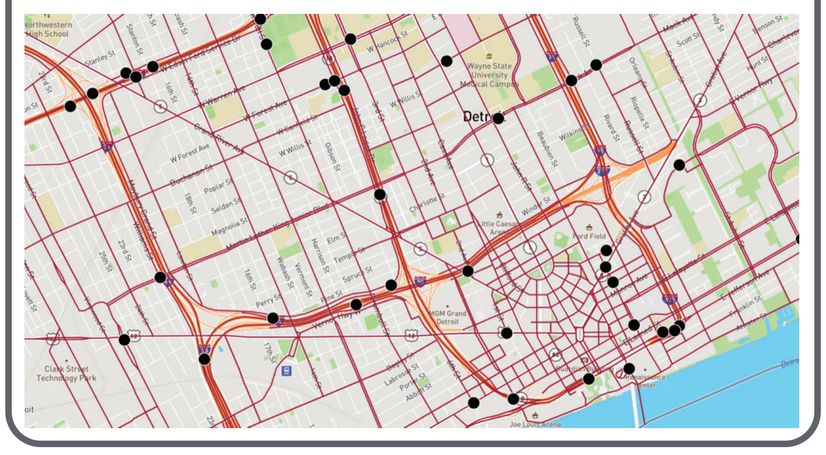
7. Second project goal

To deepen our understanding of crashes, we built a **road risk score**. Since GM does not store road data, we **web-scraped open data** about the **Detroit area**:

Data source	Size
Road features	20K road segments
Road geometry	260K road segments
Intersections	98K intersections

We **split roads into segments**, extracted **features** about them and **matched crashes** to those segments.

8. Crash locations matching

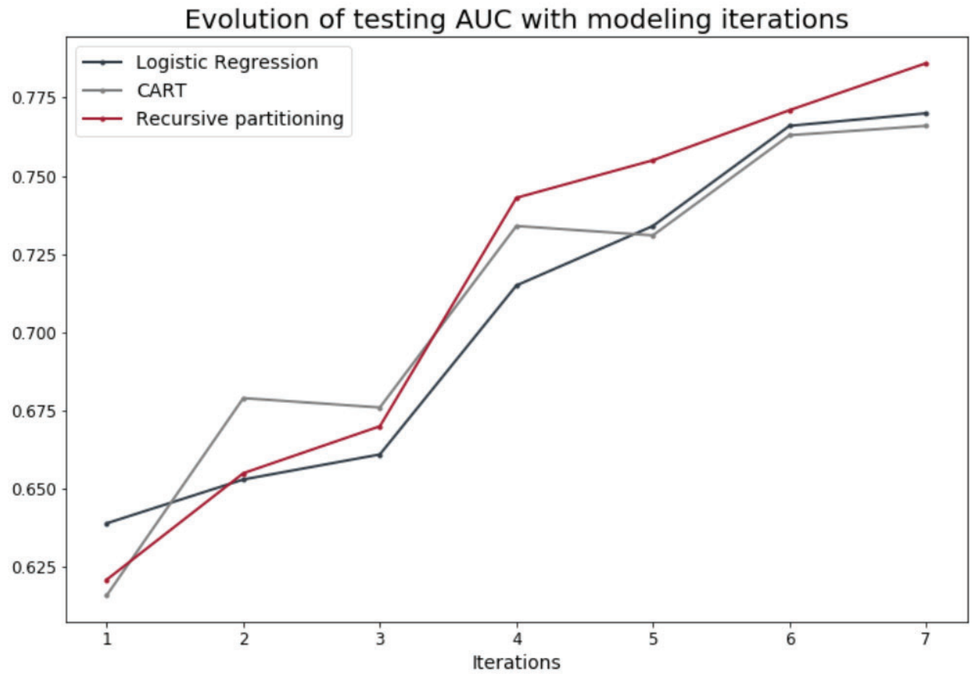


9. Road risk score impact

Our road risk score can be impactful in many ways:

- **Enhance safety awareness** and **strengthen GM's position as a safety leader** using interpretable coefficients
- **Help city-planners** decide which road to renovate and how
- **Partner with insurance companies** to reduce number of crashes by incentivizing their customers to take safer routes

10. Predictive power comparison & evolution

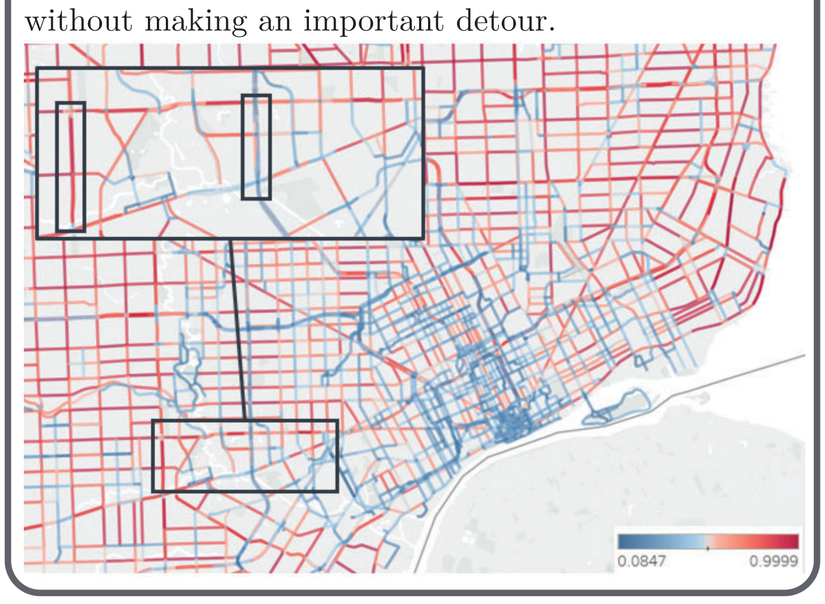


Step 1: Raw features only
Step 2: Feature engineering (binning) and spatial data imputation
Step 3: Add interactions between features
Step 4: Process intersection data
Step 5: Feature engineering: road angle
Step 6: Process GM telemetry data
Step 7: Resample the training data

Subset of features	Logistic Regression coefficients
Traffic volume	0.830
Number of intersections without traffic signal	0.576
Pavement type asphalt	0.278
Number of intersections with traffic signal	0.200

11. Re-routing to safer routes

The plot of Detroit's road risk score shows **consistency from a segment to the next one**.
Moreover, it is often possible to **find a safer route** without making an important detour.



Conclusion and recommended next steps

We investigated the **driver, vehicle and road's impact on safety** and potential use cases.
For the first project, we recommend to apply our framework to find the real effect of **weather** and the effect of **loud radio volume on safety**.
GM should also start **engaging insurance companies** with both projects to **reduce crashes and monetize its data**. In particular, our first product can help insurance companies adapt safety option pricing, while our road risk score product can be turned into a **white-label app** and used to incentivize customers to take safer routes.
To achieve the **zero crashes goal**, GM should build a **personalized road risk score** that would lead to the **safest routing algorithm**: first, find features that are relevant to safety using our first product's framework, then incorporate them into our second product's risk score model that would be **unique to a driver in a given vehicle**.