Data Analytics in the Connected Vehicle Future to Revolutionize Safety, Emissions, and Funding

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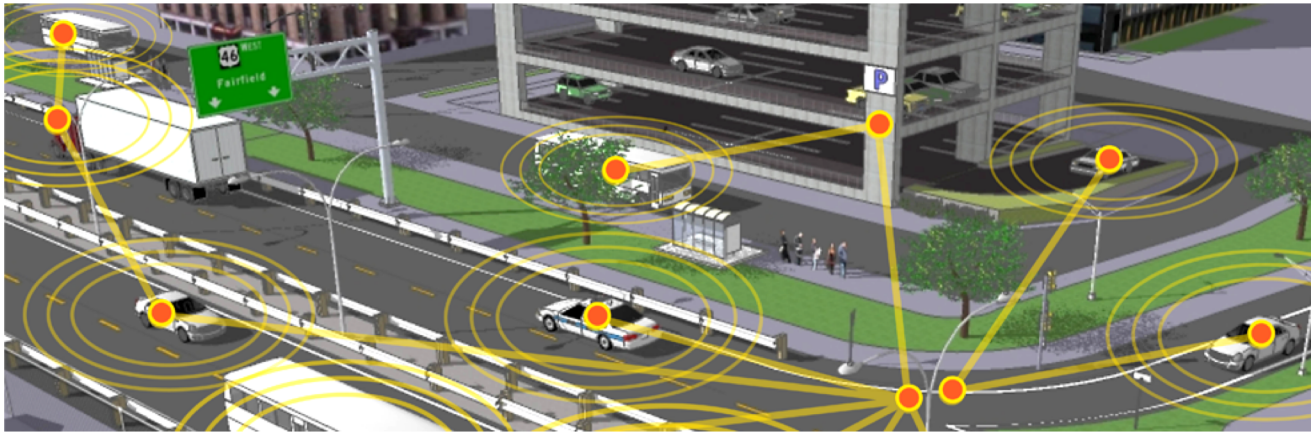
Internet of Things (IoT) / Connected Vehicles Era

- Many of the suggested services are user-centric
  - But many have very high capital costs to implement
- Some have far more social benefits than others
  - With agencies are the ones I care about



Source: Volpe Research Center

Safety and Environmental Emissions are a Big Challenge

- In 2011, 5 million car crashes, 2 million injuries (including 100,000+ pedestrians and cyclists) and 32,000 fatalities (including 4,400 pedestrians)

- Transportation is a leading cause of conventional air and greenhouse gas emissions (5-60% and 28 %, respectively)

Source: DOT and TTI

Major Policy Instrument in Reducing Fatalities, Emissions : Periodic Inspections

- Purpose: identifying non-compliance to a standard
- Done at an inspection location (station, dealer, etc.)
- In US, neither inspections are nationally required

- Safety – states opt-in, but decreasing participation
- Emissions – done primarily in urbanized areas
  - For both, inspections done by driving to a test facility
  - Frequency (often annual), rigor of programs vary

Safety Inspection 101: What Components Are Checked?

- Tires (tread)
- Brakes
- Lights

- Wheels
- Suspension
- Steering
- Battery
- Mirrors

Source: autotraining.edu

- **Point is, there is a requirement that must be met**

Data

- We have all safety and emissions inspection data from Pennsylvania (and registration info) for last 15 years
  - About 100 million records

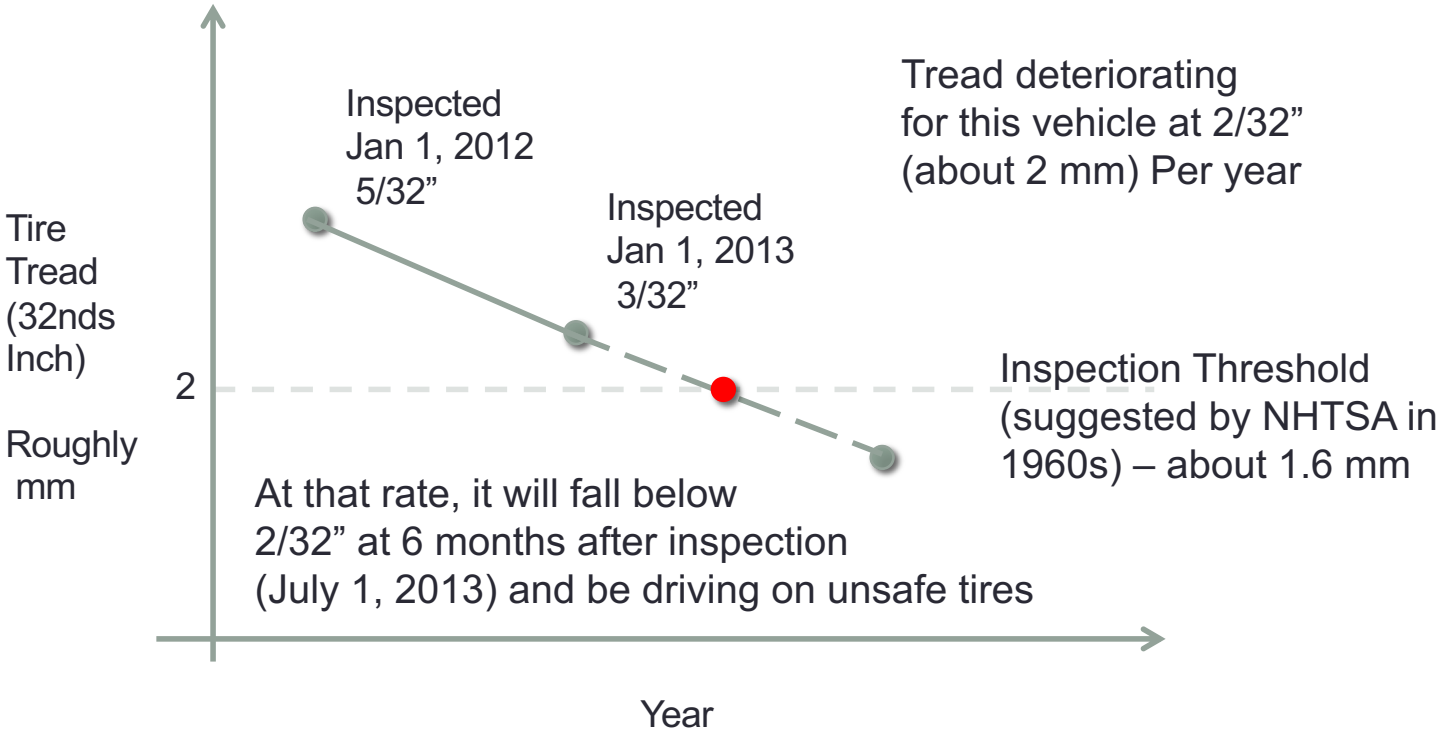
- We have created a large data analytics engine to efficiently process specific fields of the data to answer a range of relevant and interesting questions
  - **Initially had only been focused on finding failure rates..**

But Can We Drill Down and Answer Much More Specific Questions?

- We wanted to leverage our analytics engine for each vehicle inspection category to demonstrate what kinds of data-driven analyses are possible.
- Chose a hot topic – tire tread inspections

- **Example Questions**:
  - What is the deterioration rate of tire tread in passenger vehicles?
  - Given inspection thresholds, how many cars would be expected to be “below threshold” before their next annual inspection?
  - How many are potentially driving around on ‘unsafe’ bald tires?
  - Should we modify the way we inspect tires?

Data-Driven Tire Tread Deterioration Motivating Example for a Single Vehicle



Deterioration Model Overall Results

- Analyzed records in safety datasets (2008-2016)
  - About 17 million inspection records / 4 million unique vehicles
  - Historical vehicle level analysis of tire tread deterioration rates
  - Inspection records also have odometer readings (so can track fleet driving, deterioration rates can be found by mile also)

- Summary Results:
  - Overall average rate: -0.2 (32^{nd} of inch, or mm) per 1,000 mi.
  - Given average 10,000 VMT, that is 2/32” per year

Projections and Policy Analysis

"What Does This Mean"

- Expect average car at 4/32" (4mm) at time of an inspection to need new tires before next inspection.
  - Drivers who don't do routine maintenance will be driving on unsafe tires soon after the inspection.
- A fixed inspection threshold 2/32" might not be anticipating problems for cars that will dip under the threshold soon after their inspection (and drive around for nearly a whole year)
- Data shows about **25%** of cars are at or below 4/32" at time of inspection, so will "need new tires" before next inspection.
- From the inspection records, only 40% of owners are proactively changing tires before the next inspection

Potential applications

- Easy but broad: raising thresholds for all (e.g., 4 or 5/32”)
- Easy but targeted: different thresholds for different types of passenger vehicles (cars vs. SUVs)
- Hard but targeted and disruptive:
  - Collaborating with our state on a dynamic algorithm for threshold for each vehicle, that considers estimated VMT at time of inspection (as done for emissions exemptions)

CV Technologies Will Help Emissions

- We have tests for check engine light status, and 95% of vehicles *pass*.

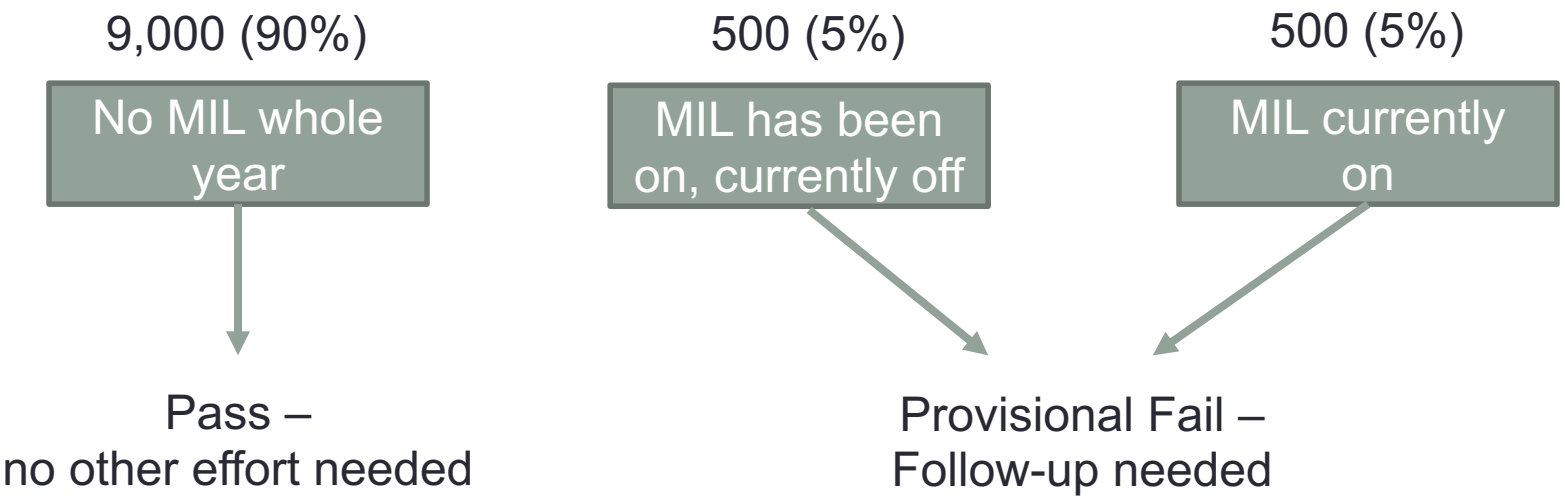
  - So 95% of the user costs are verifying things drivers know
  - Opponents are right – these programs ARE wasteful ($35 for 2 mins)

- Some states have low-level “Remote Programs” (remotely access an OBD scanner and report results over web)
  - Still “once a year” to maintain fairness of existing program

- But imagine a ***disruptive*** CV-enabled system where MILs (and other vehicle parameters) are continuously monitored
  - Can focus all efforts just on the “5% of problem vehicles” – others don’t even have to go to an inspection station

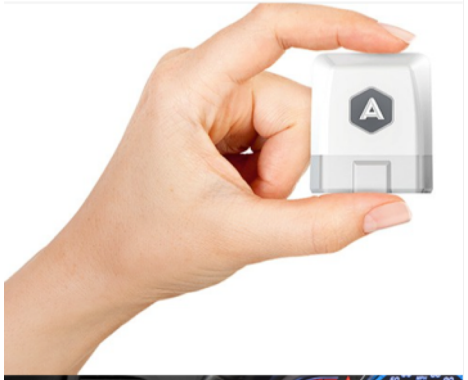
A Specific Thought Example..

- Imagine: I have once a week data on the MIL of 10,000 vehicles over a year



- User costs reduced ~90%

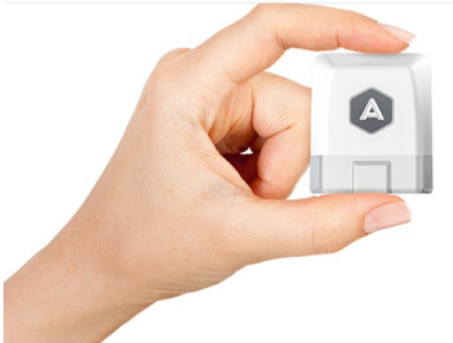
We Don't Need to Rely on Manufacturers



- We suspect states would be wary of partnering with them after emissions scandals
- Also interested in leveraging data from on-board OBD dongles (e.g., Automatic).
  - Smartphone or 4G connected
- Use their existing data streams to periodically track OBD status (and other information like vehicle 'trouble codes')
- These technologies also provide data streams of vehicle use at the *trip level* (mileage, fuel use, ..)

And Quick Thoughts on Using CV Data Streams for Mileage-Based Fees

- Can help to solve part of the funding problem
  - But we're still stuck with no revenue from vehicles using low fuel
- Even with inspection data, we are able to make full profiles of VMT of vehicles at time of inspection
  - Just subtracting odometer readings
- But also emerging data streams from these CV devices at trip level
  - Can envision pilot projects, prospective analyses
  - What would fees and funding have to look like?



Challenges at Scale

- Transportation has many exciting applications of emerging methods, some not so obvious to people
- This is not a technology problem. It's a technology *deployment* problem.
  - Can we really replace inspectors with algorithms? (Can we replace humans?)
  - How to transition currently employed inspectors?
  - Can we do all of this in "real time"?