

USING “BIG DATA” TO BETTER DESIGN AN ELECTRIFIED VEHICLE 以“大数据”改进电气化车型设计

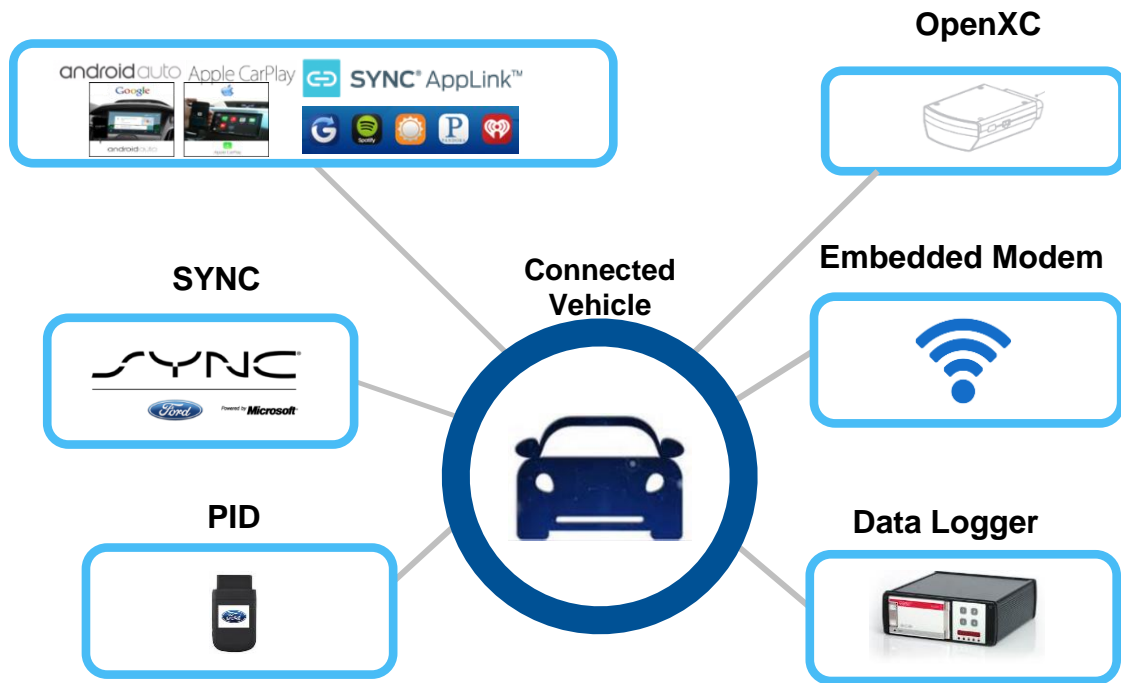
Brett Hinds

Chief Engineer - Electrified Powertrain Engineering
Ford Motor Company



CUSTOMERS AND THEIR BIG DATA 客户端的大数据

Connected Vehicle Technologies

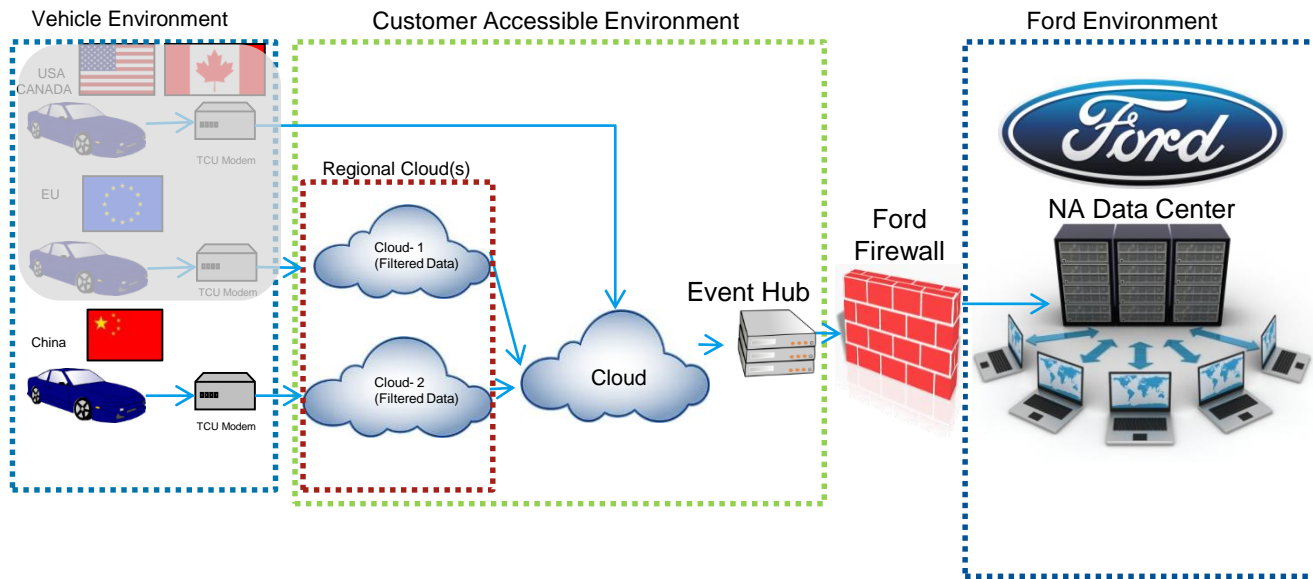


Ford is a leader in the connected vehicle space
Number of technologies and methods are currently used to obtain data from vehicles

MYFORD® MOBILE AND FORDPASS® MYFORD® 及 FORDPASS® 福特派



- Embedded Modem technology
- Event based data collected



Data is anonymized and stored in secure servers internally at Ford
Restricted access to any personally identifiable information such as VINs, GPS coordinates etc.

A NOTE ON DATA PRIVACY

Globally, Ford subscribes to the Alliance of Automobile Manufacturers Consumer Privacy Protection Principles.



- Agreement governing the collection, use, and sharing of certain vehicle data.

There are specific considerations for the data collected in the China market specifically focused on – GPS/Mapping

- Foreign entities are completely forbidden from mapping activities, which includes any measuring, collecting, and presentation of shape / size / spatial position or properties of natural geographic elements.

Cyber Security Law

- Focused on protecting customer data and having explicit customer consent for any use of this data, including overseas data storage, marketing, and analytics.

Banking / Financial Data

This report only contains analysis done on non-China data only on an aggregate basis.

BIG DATA ANALYTICS: TOOLS & WORKFLOW

大数据分析：工具及协同



It takes more than a hammer to build a house

Why use Big Data? 为何使用大数据？

Gaining understanding of how customers will use electrified vehicle is invaluable in **designing**.

- How many Wide Open Pedal operations per 100 mi exist? Is it different for a performance product?



New technologies with very little **quality** history drive need for data to develop effective KLTs.

- How often and how much power is derived from the high voltage battery?



Electrified components are generally expensive and right-sizing them can provide best **value** to the customer as well as the OEM.

- Right size the battery for electric drive.



Big Data can be used to benefit designing products, adding value, and improving quality.

Examples of Big Data Projects 大数据项目举例

1. **Battery Charge Power Limit**
2. **Charger Sizing**
3. **WOP Occurrence**
4. **Powertrain Efficiency**

Example 1: Battery Charge Power Limit

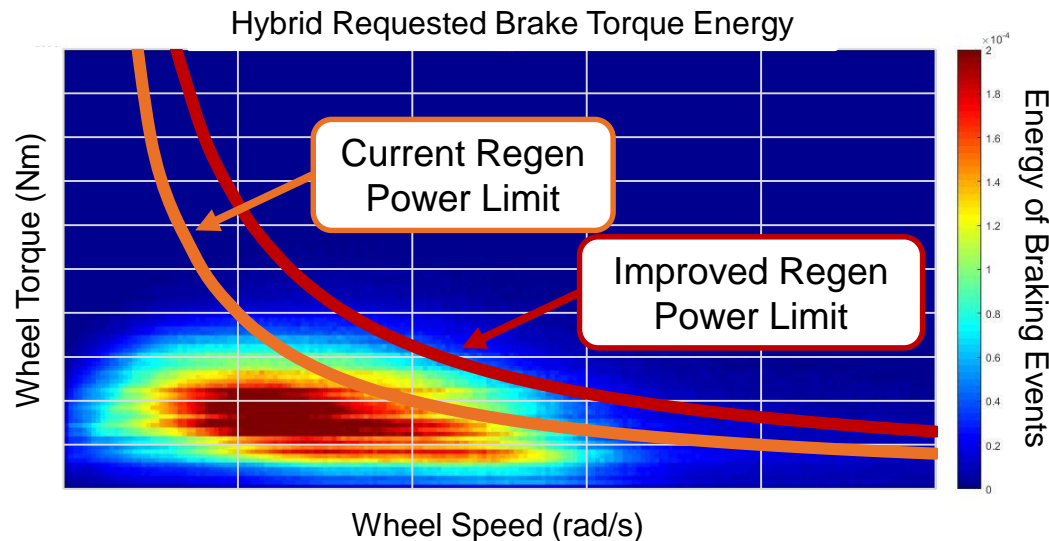
例一：电池充电功率限值



Design:

- Set battery charge power limit to collect not only most of the regen from regulatory cycles, but also real world customer drives
 - Opportunity to increase regen power limit comes with e-AWD systems

20,987 trips	10 Hz frequency	1.02 million miles	765 million rows of data
--------------	-----------------	--------------------	--------------------------



放宽了再生制动充电功率的上限之后，回收的能量最大可提升到原来的27%

Up to 27% increase in available energy capture with increased regen braking power limit.

Example 2: Charger Sizing

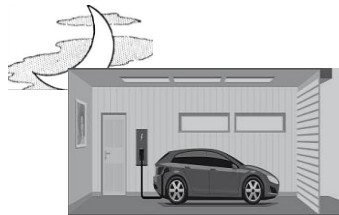
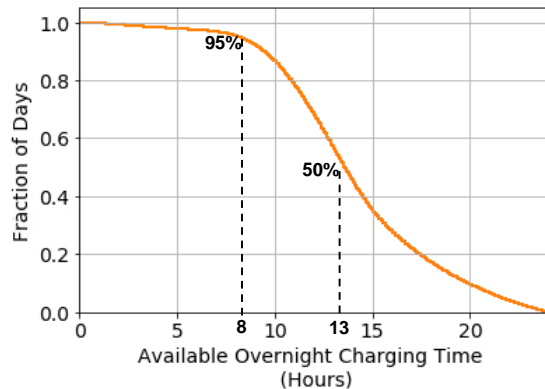
例二：车载充电器功率



Design:

- Determine on-board AC charger size for a 300 mi electric vehicle

Traditional Method: Size charger to fully charge battery regardless of next day's driving distance



95% of the nights have at least 8 hours of available charging time.

Overnight Charging

Remaining range at start of charge: 0 miles

Miles to be added: 300 miles

Charge time required: 13 hrs (assumes a 7kW charger)

To charge in 8 hours, a ~11kW charger would be needed

仅有~50%的情况下，隔夜能有13个小时用于充电。因此很可能要选用更大功率的车载充电器。

Only ~50% of the nights have 13 hours or more available for charging.
This will likely result in opting for a bigger charger.

Example 2: Charger Sizing

例二：车载充电器功率

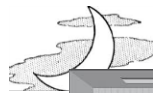


Design:

- Determine on-board AC charger size for electric vehicles such that next day's distance is fully charged overnight

Data Driven Method: Size charger so as to cover the next day's distance

1. Night



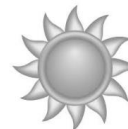
Start of Charge: 33 miles

Charge Duration: 8* hrs

Miles added: 184 miles (with 7kW charger)

* 95% of nights have at least 8 hours available for charging

2. Day



Start of Drive: 217 miles

A Long Drive: 200* miles

* 95th Percentile US Customer drives < 200 miles

3. Night



End of Trip: 17 miles

Charge Duration: 8 hrs

Miles added: 184 miles (with 7kW charger)

End of Charge: 201 miles

充电器的功率选择可以达到较高的成本效益，满足95%的用车需求。其它对里程需求更长的场景，可以通过直流快充来满足。

Charger can be cost-effectively sized to cover the 95th percentile of the scenarios. Remaining scenarios can be enabled through DC Fast Charging.

Example 3: WOP Occurrence

例三：全油门的使用



Design:

- Determine WOP occurrence rate and duration for BEV battery and thermal requirements



油门踏板开度90%以上即为全油门。

性能车型每100英里会出现 2.77次全油门的使用。

WOP event is one where the pedal position goes to greater than 90%.

Performance vehicles experience 2.77 WOP events per 100 miles

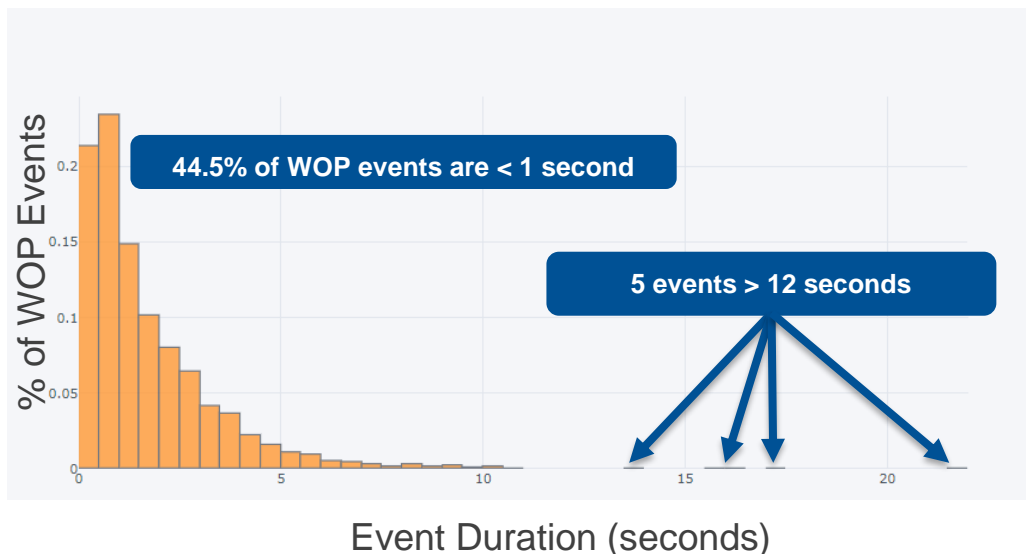
Example 3: WOP Occurrence

例三：全油门的使用



Design:

- Duration of WOP events have direct implications on thermal requirements



通过车联网数据分析发现，典型全油门的使用通常会小于 5 秒。

From connected vehicle data analysis, the typical duration of WOT events is generally less than 5 seconds.

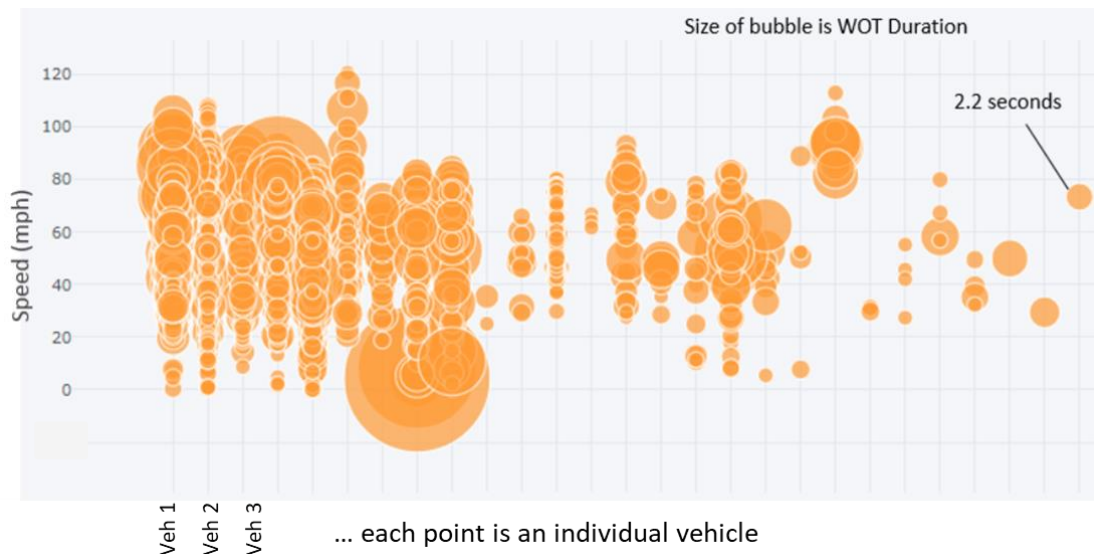
Example 3: WOP Occurrence

例三：全油门的使用



Design:

- For power consideration, the duration and speed of a WOP events is considered.



全油门发生时的车速也是一个设计考虑的因素 — 同样来源于大数据分析。

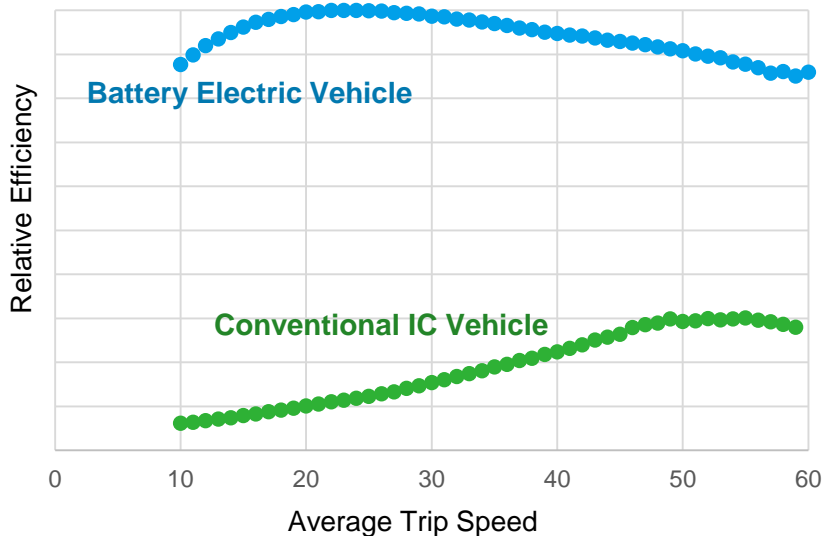
Speed at which WOT event occurs is another design factor – also enabled through big data.

Example 4: Powertrain Efficiency

例四：动力系统的效率

Value:

- Study of the relative efficiencies of a electrified powertrain vs. a conventional powertrain for different average trip velocity.



纯电动的动力系统相比传统动力系统，峰值效率发生在低速段。平均车速较低的国家，如中国，使用纯电动汽车会更有益。

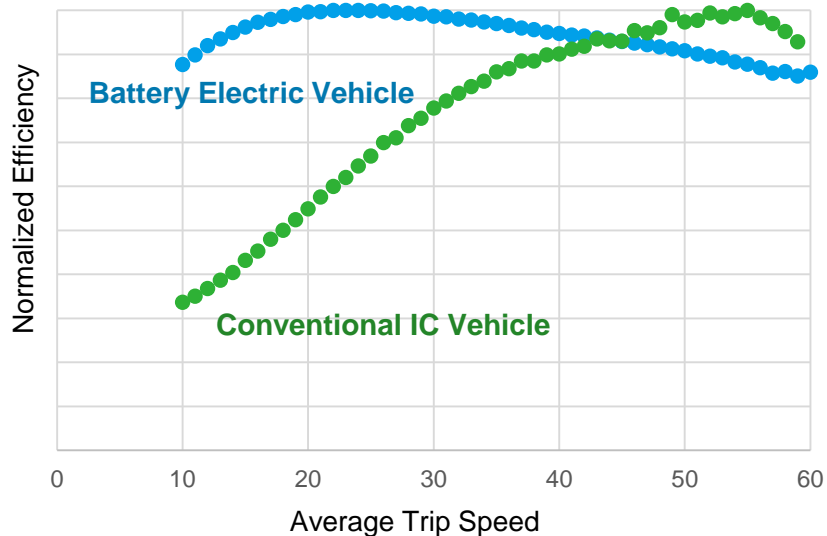
BEV powertrains have peak efficiencies at low speeds compared to conventional powertrains. Low speed markets, like China, can benefit more from BEVs.

Example 4: Powertrain Efficiency

例四：动力系统的效率

Value:

- Study of the relative efficiencies of a electrified powertrain vs. a conventional powertrain for different average trip velocity.



此外，纯电动动力总成受平均车速的影响，
相比传统动力总成来说更小。

Moreover, BEV powertrains are less sensitive to average
trip speed compared to conventional powertrains.

USING BIG DATA

大数据的使用

Appropriately sizing the powertrain for a PHEV or BEV is a delicate balance between regulation, cost, and customer wants.

- Data collected from vehicles can help OEMs set the right balance for designing the vehicle.

There is a growing need in the automotive industry to standardize the analysis of this data.

- SAE can take the initiative for this globally by setting up data analysis standards and procedures.

SAE PAPER REFERENCE

SAE文献参考

2017-01-0247 - Big Data Analytics: How Big Data is Shaping Our Understanding of Electrified Vehicle Customers

2017-01-1146 - Seasonality Effect on Electric Vehicle Miles Traveled in Electrified Vehicles

2017-01-0235 - Customer Data Driven PHEV Refuel Distance Modeling and Estimation

2018-01-1202 - Using Machine Learning to Guide Simulations Over Unique Samples from Trip Profiles

2018-01-0427 - Charger Sizing for Long Range Battery Electric Vehicles



Abstract

Electric vehicles are highly sensitive to variations in environmental factors (like temperature, drive style, grade, etc.). The distribution of real-world range of electric vehicles due to these environmental factors is an important consideration in target setting. This distribution can be obtained by running several simulations of an electric vehicle for a number of high-frequency velocity, grade, and temperature real-world trip profiles. However, in order to spend up simulation time, a unique set of drive profiles that represent the entire real-world data set needs to be developed. In this study, we consider a unique velocity and grade profiles from various real-world applications in EU. We generate scenarios that describe these profiles using trip

descriptors variables. Due to the large number of descriptor variables when considering several other effects, we formulate each descriptor and use principal component analysis to reduce the dimensionality of our dataset to its components. This is based on achieving a high explained variance ratio. Clustering is then performed on the dataset using the k-means algorithm implemented in Scikit-learn. We select sample representative trips by optimizing between the inertia obtained from the k-means algorithm and the explained variance ratio of principal component analysis. The number of representative trips selected is also driven by the performance of simulations for real-world range calculations. Range simulations can now be performed on these selected representative trips to obtain a distribution of expected real-world range.

Introduction

With increasing regulations on fuel economy, consumer interest in greener technologies and other market factors, there is a renewed interest to increase the market share of electrified powertrains [1]. One of the approaches being considered to achieve an increased market share of electrified powertrains is their introduction to different vehicle segments such as cargo vans and trucks. Electrified vehicles typically have an electrical energy input and path to the wheels, either in place of or in addition to the gasoline fuel energy and mechanical path in conventional internal combustion engines [2]. Their electric vehicles, known as Battery Electric Vehicles (BEVs), only have an electric energy storage device (i.e. battery) that provides mechanical energy to the wheels through an electric motor. Fully Hybrid Electric Vehicles (FHEVs) have a chemical energy from gasoline either to provide mechanical energy to the wheels or to store for later use through an onboard battery or capacitor to increase the overall powertrain efficiency. In Plug-In Hybrid Electric Vehicles (PHEVs), electric energy is stored using an onboard battery along with chemical energy from the fuel to be used in conjunction with the battery.

In the real world, customer experience varying efficiencies and conversion of onboard energy is a common trend. One of the main reasons for this variation is ambient temperature. The effect of temperature is more pronounced on electrified

vehicles due to their high efficiency [3]. This results in BEV and PHEV customers experiencing greater deviation from the label electric vehicle (EV) range values. Previous work has helped quantify the effects of temperature on electric vehicles [4]. In this work, we aim to help original equipment manufacturers (OEMs) understand the distribution of real-world electric range of electrified vehicles by developing a method to select representative trips for electric range simulations.

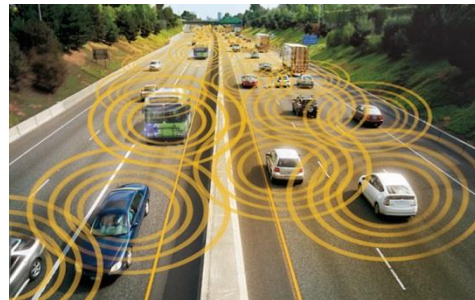
Variation in electric vehicle (EV) range in the real world can be readily observed, as shown in Figure 1. This figure shows that there is a relatively wide spread of the on-road EV range observed, typically centered around the EPA label value. EU certification cycle, the NEDC is typically on the higher end of the on-road EV range. When designing a new electrified powertrain, there is a need to get an accurate representation of the spread in on-road EV range. Simulations of real-world trips are usually performed to understand the impact of various factors [5]. These simulations are typically standardized models of a chosen electrical platform, which use an input of velocity, grade, track, and wind, and estimate the fuel consumption over real-world trip. However, to generate a distribution of on-road EV range from real-world trips, these simulations will need to be run on a large number of real-world trips to capture the variation in EV range. This exercise can be time-consuming, and wasteful if two similar trips are simulated.

CONCLUSIONS

结论

Insights learnt from data collected from connected vehicles can be used to –

- Appropriately **design** the next EV
- Develop effective test methodologies for robust **quality**
- Right sizing components for best **value** to customer



Common, agreed-upon methodologies to analyze the data will become necessary.

- SAE can play a vital role in developing data analysis standards.

我们都应该仔细聆听汽车大数据的声音！

We should all listen carefully to what the vehicles are telling us!