HBM Prenscia Technology Day

Virtual Seminar Series

Application of a Vehicle Data Simulator to Big Data CBM Systems

Presented by Mr. Iain J. Dodds
Head of Integrated Solutions / Technical Fellow, Prenscia Engineering Solutions

Session #4: Vehicle Fleet Data Analytics

Application of a Vehicle Data Simulator to Big Data CBM Systems

Abstract

When designing and testing large Condition Base Monitoring (CBM) type systems (10,000+ assets) an important step is to ensure the system can handle the expected volumes of data and can sustain growth as more assets are added over time. When commissioning a new system, customers typically do not have 10,000+ assets instrumented in the field producing data on a daily basis, and the process of asset onboarding can be expensive and have long lead times. In order to design and build large usable CBM systems, alternative methods are needed to generate a suitable volume of asset data that allows engineers to configure and test the system prior to investing in large-scale “real” asset onboarding. This data needs to be representative of actual usage/conditions while having sufficient variability from asset to asset, channel to channel, day to day etc. Achieving this representative data volume is more than simply duplicating existing sample records.

This presentation discusses the implementation and usage of a Vehicle Data Simulator. This simulator allows for the generation of multiple vehicle operational data sets that contain sufficient data variability while being representative of real vehicle operating conditions. The data from the simulator draws from many external sources and is of suitable fidelity that it can be used within the CBM system for detailed calculations and derivations similar to those performed with real vehicle data. Although this simulator focuses on the creation of wheeled vehicle operational data, the methods described in this presentation could easily be adapted and applied to alternative asset groups such as tracked vehicles, rail vehicles or aircraft. The Vehicle Data Simulator design and usage scenarios will be presented.

About the presenter, Mr. Iain J. Dodds

Iain Dodds has over 25 years of experience in the implementation, development and deployment of enterprise level engineering software systems. His broad experience spans multiple domains including Road Load Data Acquisition (RLDA), Computer Aided Engineering (CAE), Knowledge Based Engineering (KBE), Product Lifecycle Management (PLM), vehicle telematics systems & services and scalable data monitoring & managements systems.

Iain holds an MSc in Engineering Design from Napier University, Scotland, UK and a BEng (Hons) in Mechanical Engineering from Heriot-Watt University, Scotland, UK..

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HBM nCode Federal LLC

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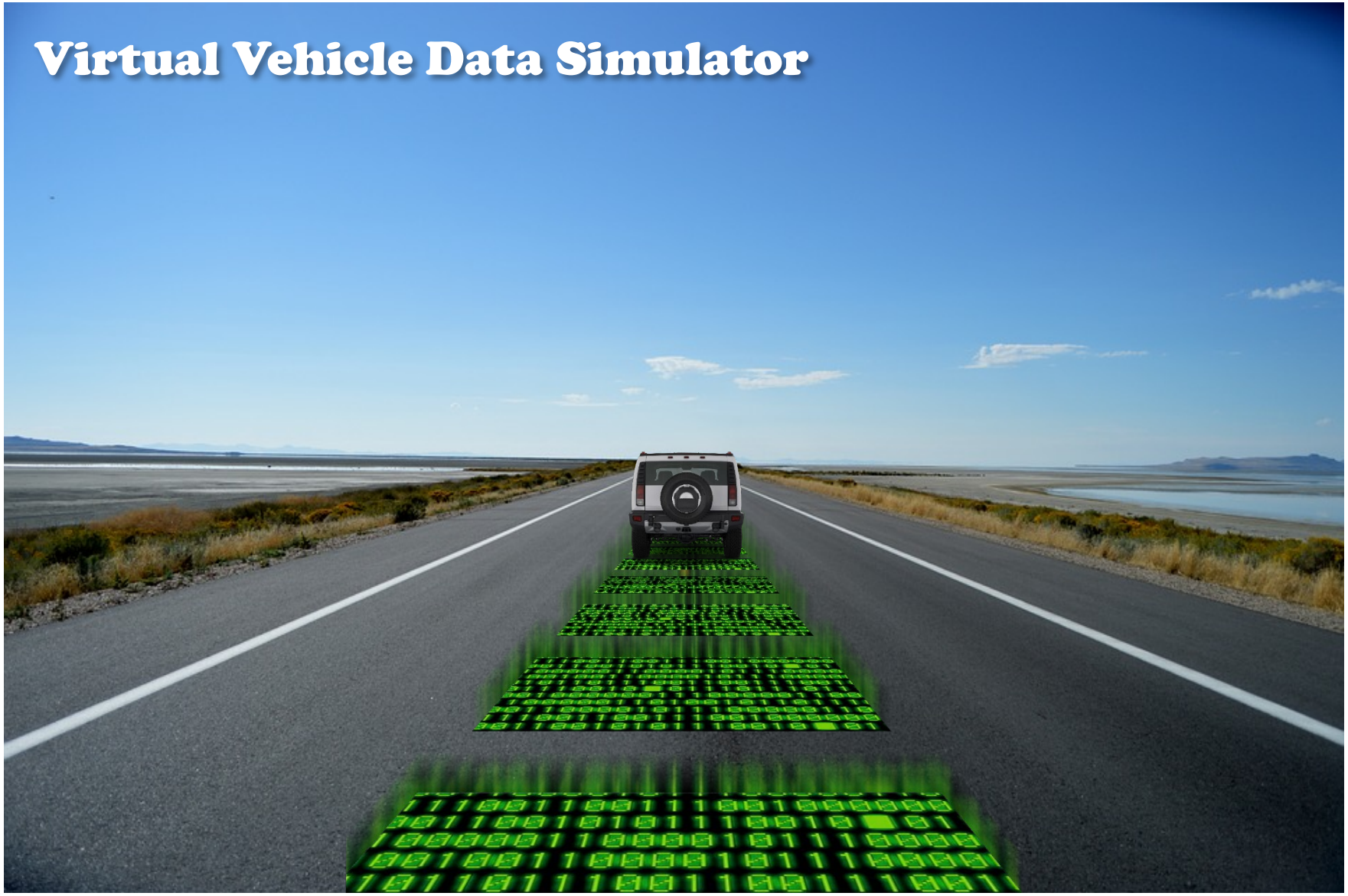
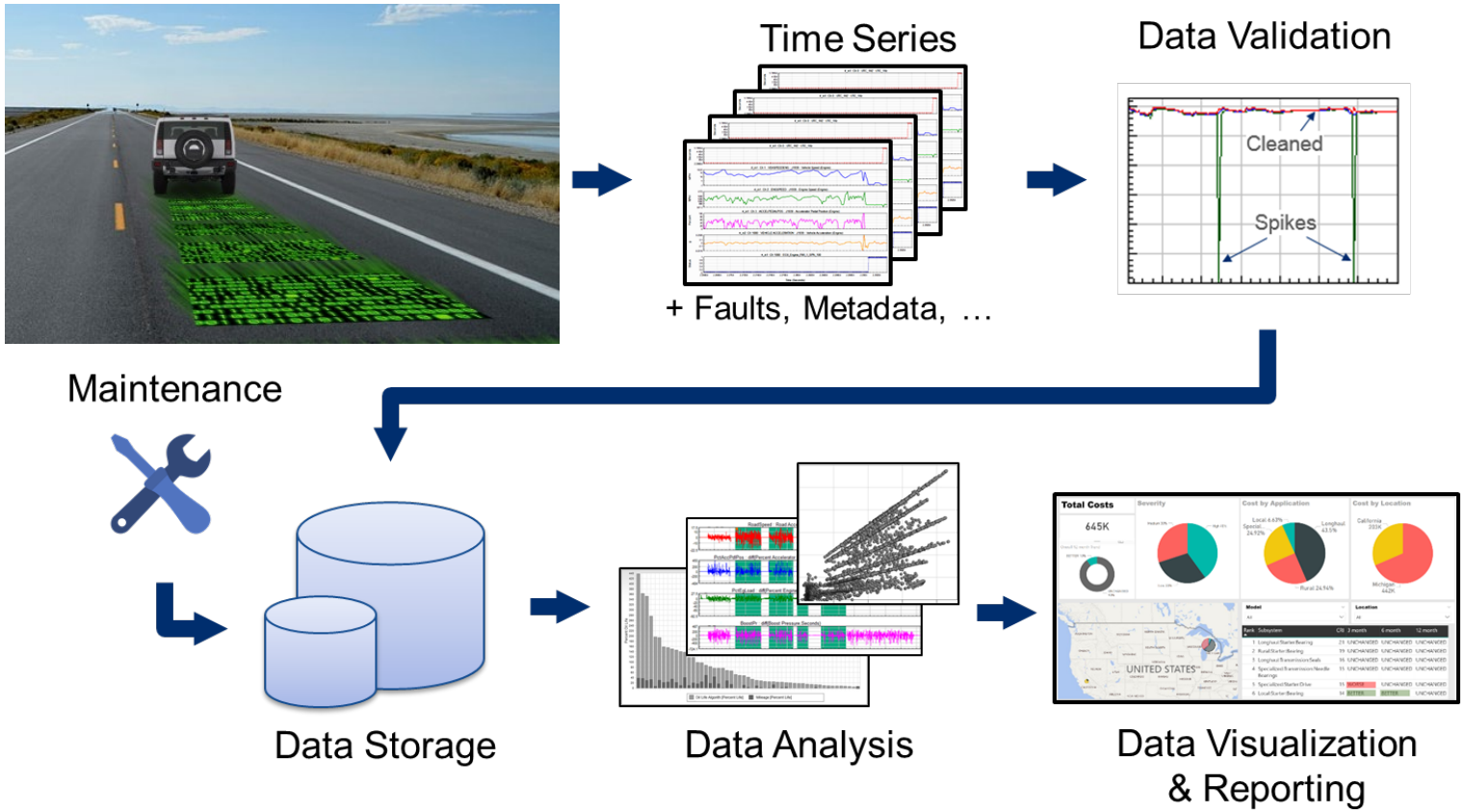
Virtual Vehicle Data Simulator

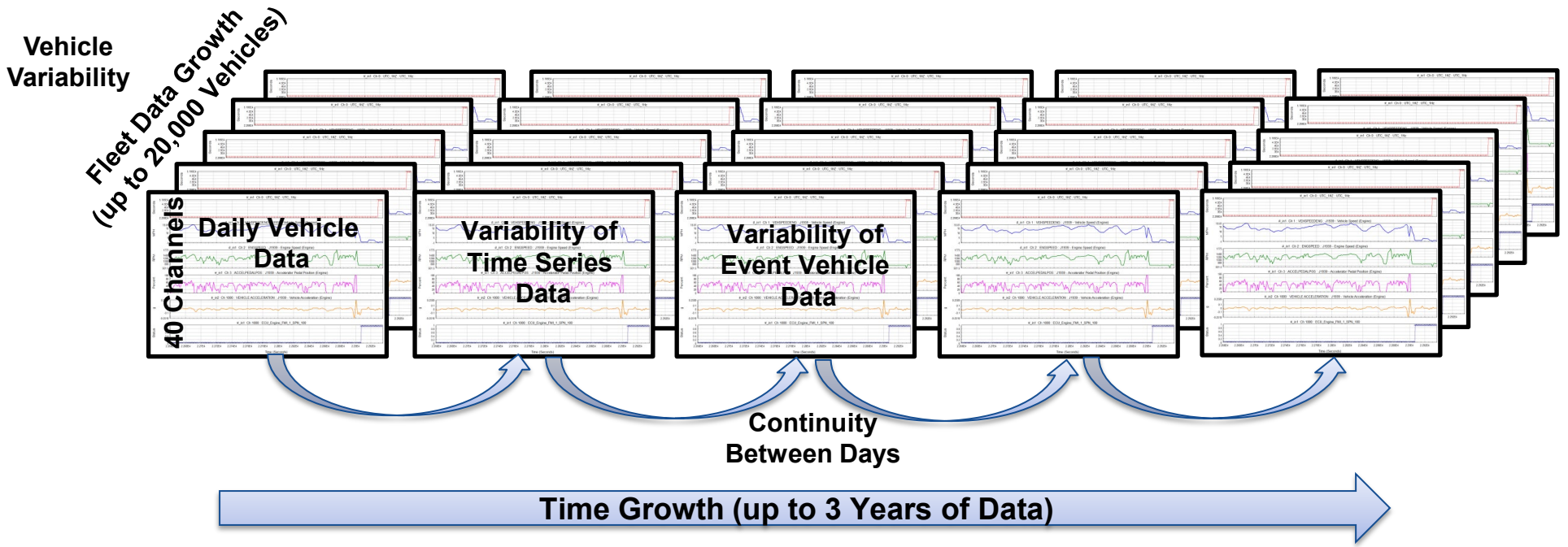


Testing System at Scale… *Virtual Vehicle Data Simulator*

Generate vehicle data virtually to test a larger system



Task 1 – Generation of Representative Data Set



Data Generation Options

		Pros	Cons / Challenges	Score
1	***Duplicate Existing Files***	• Demonstrates Volume	• May not be enough variation for meaningful analysis • Limited maintenance data linked to TS data • **Data Ownership** - Limited usage commercial demonstrations / projects	40%
2	***Collect own data***	• Real data for analysis • **We own** the data	• Time consuming and costly to collect • Initially not be enough to demonstrate volume • Maintenance data linked to TS data would need to be collected	70%
3	***Identify events from existing data and remix to generate usage profiles***	• Demonstrates Volume	• Data continuity • May not be enough variation for meaningful analysis • Lack of maintenance data linked to TS data • **Data Ownership** - Limited usage commercial demonstrations / projects	70%
4	***Develop a data generator***	• Demonstrates Volume • **We own** the data	• Need good understanding of inter-channel dependencies to make it look real • Lack of maintenance data linked to TS data • Data not real enough for meaningful analysis??	70%
5	***Buy More Data***	• Demonstrates Volume • Real data for analysis	• Hard to find source • Could be costly • May not have exclusive **ownership** / rights	20%
6	***Request additional data files from Army***	• Real data for analysis	• Difficult to obtain if source is not involved directly with the project • May still not be enough to demonstrate volume • **Data Ownership** - Limited usage commercial demonstrations / projects	60%
7	***Obtain from another source / OEM***	• Demonstrates Volume • Real data for analysis	• Difficult to obtain if source is not involved directly with the project • **Data Ownership** - Limited usage commercial demonstrations / projects	20%

High Level Problem Statement / Requirements

- Generate a representative dataset at volume for a fleet of vehicles that:
  - ✓Looks realistic and unique for each trip / dataset
    - ✓Not just multiple copies of an existing an data file
  - ✓Has the ability to include variability into the simulation
  - ✓Maintains a relationship between channels (RPM / Speed / Gear / temps) based off a simulation model
  - ✓Is tunable to different vehicle parameters
  - ✓Can generate output data in various formats (ASCII, CDF)
  - ✓Produce signals at various sample rates
  - ✓Can generate datasets faster than real time

  - Can introduce data anomalies into the signals that can be used to test our data cleanup routines
  - Simulate startup and stop conditions (i.e. ignition)
  - Simulate DTC
  - Simulate maintenance history

Vehicle Input Parameters & Configuration

- **Control Inputs**
  - Accelerator position
  - Brake position
  - Steering wheel angle (*Currently not used*)

- **Setup / Configuration**
  - Driving Style
  - Vehicle On/Off delays
  - Number of gears
  - Gear Shift Points (Automatic Trans only)
  - Air Drag Coefficient
  - Engine Drag Coefficient
  - Brake Constant
  - Engine Force Factor
  - Engine to Torque Factor
  - Car Mass Factor
  - Fuel Tank Size
  - Fuel Consumption
    - Max and Idle

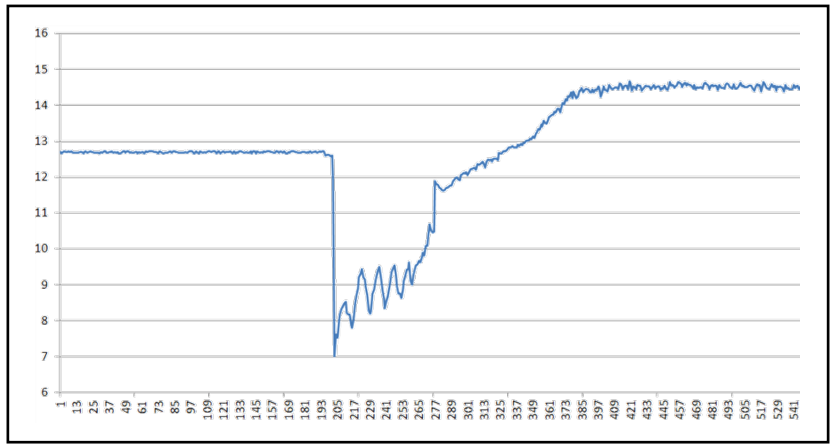
Supported Data Channels

- ✓ UTC
- ✓ GPS Time Stamp
- ✓ Latitude
- ✓ Longitude
- ✓ Altitude
- ✓ GPS Speed
- ✓ Heading (course)Accelerator Pedal Percentage
- ✓ Vehicle Speed
- ✓ Engine Speed (rpm)
- ✓ Coolant Temperature
- ✓ Engine Load
- ✓ Brake Pedal Position
- ✓ Accelerator Pedal Position
- ✓ Transmission Gear (First, Second, Third etc.)
- ✓ Fuel Level
- ✓ Odometer
- ✓ Barometric Pressure
- ✓ Ambient Temperature
- ✓ Oil Temperature
- ✓ Oil Pressure
- ✓ Fuel Rate
- ✓ Ignition Status (Off, Accessory, Run, Neutral)
- ✓ Headlamp Status
- ✓ Battery Voltage
- ✓ Transmission Temperature
- ✓ Vehicle Pitch
- ✓ Vehicle Roll
- ✓ Vehicle Yaw
- ❑ Fuel Consumed Since Restart
- ❑ Alternator Voltage
- ❑ Engine Torque
- ❑ Injector Control Pressure
- ❑ Transmission output shaft speed
- ❑ Transmission torque converter status

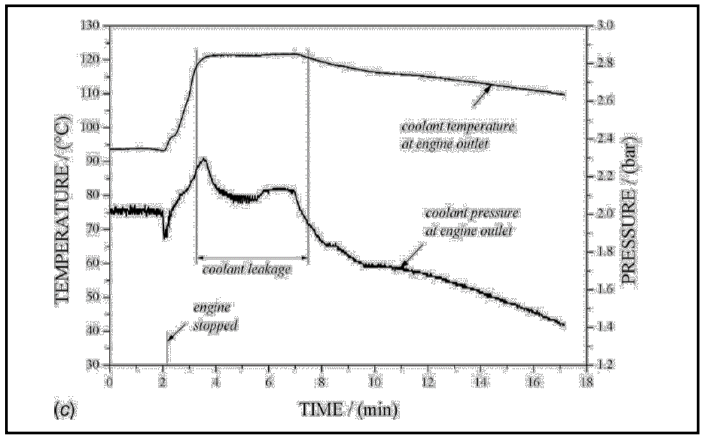
- • Parking Brake Status
- • High Beam Status
- • Steering Wheel Angle
- • Windshield Wiper Status
- • Door Ajar (Driver, Passenger, Right Rear, left Rear)

✓ *Implemented in model and recorded*
❑ *To be Implemented*
• *In model but not recorded*

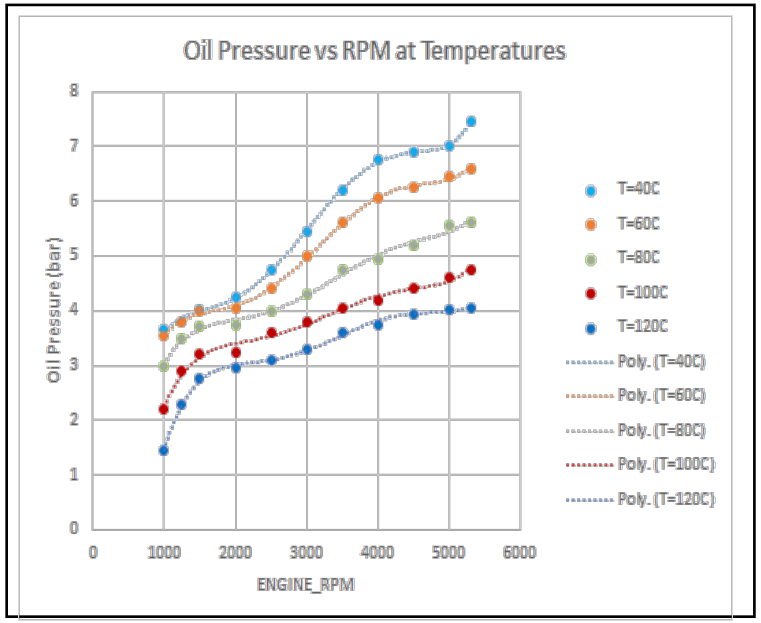
Channel Math Models - examples



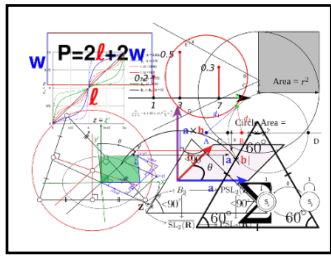
Battery Voltage Model



Engine Cooling Model



Engine Oil Pressure Model



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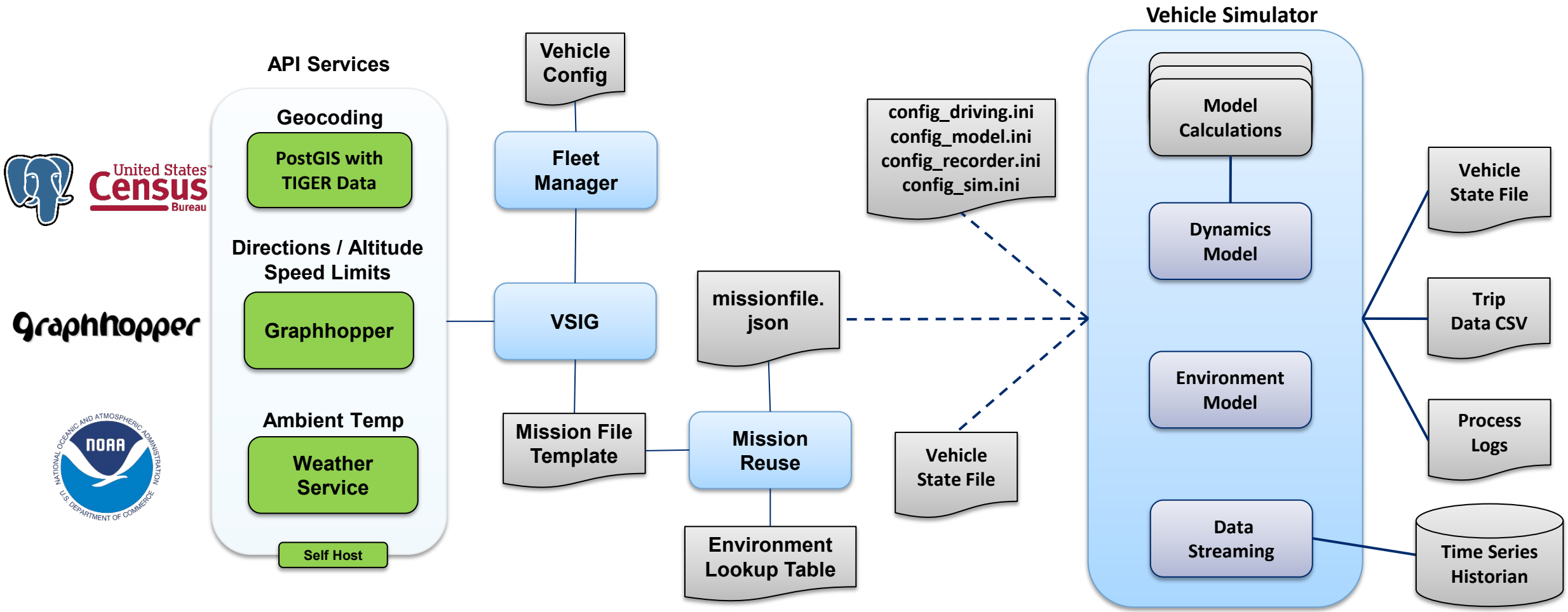
Vehicle Data Simulator Architecture V2



USAGE:

- **vsig -vin="SVIN00201" -start="26555 Evergreen Rd, Southfield, MI 48076" -end="Detroit Metropolitan Wayne County Airport (DTW), Detroit, MI 48242"**
- **missionreuse -v SVIN00201 -d $date-$starttime -m $inputmissiontemplates -o $missionoutputdir**
- **simulator –missionfile "missionfile.json"**

Sample Output

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Virtual Vehicle Simulator - Example

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Virtual Dashboard POC

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Thank You

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Q&A

- Muhammad Afzal (Omnicell, USA)
  - What you think of using similar architecture for EV Autonomous vehicles?
    - *Yes, the simulator architecture could be adapted to simulate telemetry signals from EV Autonomous vehicles. Integration with open source tools like CARLA (https://carla.org/) could make for some really interesting enhancements.*

- Phil Irving (Cranfield, UK)
  - Did you feed back the results of the analysis to control vehicle operation in the future?
    - *The simulator generates signals that represent and align with real vehicle signals. They are based off of real physics and can be used to develop analysis algorithms and test systems at scale. Currently the simulated vehicles are not true digital twins so using this data for real vehicle operational decisions would not be accurate. Given improvements to the simulated vehicle models could lead to this but it was not the intention when the project was initiated.*

- Peter Bebbington (Brainpool Ltd, UK)
  - Have you considered using Generative Adversarial Networks GANs, to generate the data?
    - *We have not looked at Generative Adversarial Networks GANs as a way to generate synthetic data. From my brief reading on this topic it looks like an interesting area to explore.*

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