

Automated System Validation Using Telematics

2011-01-2212

Published
09/13/2011Bill Leisenring
Control-Tec LLCCaetano Calviti
Navistar Inc

Copyright © 2011 SAE International

doi:[10.4271/2011-01-2212](https://doi.org/10.4271/2011-01-2212)

ABSTRACT

Powertrain Systems development is entering a period of unprecedented challenge driven by the convergence of many factors: increasing government regulations for both tailpipe emissions and fuel economy, increased competition, reduced workforce, and tighter program budgets. This has resulted in timing compression and resource reduction that stress a typical Design-Build-Test development practice. The application of telematics and information technology to engineering development can provide the efficiency gains required for engineers to deliver a robust powertrain system in a timely manner. By automating the evaluation of a system's robustness, engineers can focus their time on problem areas during their normal development process and launch with quality. This paper will detail how this methodology was jointly applied by Control-Tec and Navistar to identify and improve system performance before production.

INTRODUCTION

Powertrain Systems development in the Heavy Duty Industry has become increasingly difficult in recent years due to tighter emissions standards, the onset of On-Board Diagnostics (OBD) requirements, increased competition, and demand for greater fuel economy. The Design-Build-Test iterative development model is no longer sustainable. The development process must change in order to effectively deliver robust solutions to demanding consumers. The application of affordable innovations in telematics and information technology to enhance the development process is one potential method to enable engineers to launch quality

products and afford fleet managers the ability to stay connected with their global fleet.

Vehicles are commonly equipped with integrated telematics systems enabling the vehicle's control system to record system data and send it to a back office system for analysis¹ autonomously. These systems can be used for diagnostics and prognostics but are typically limited in providing the depth of information required to solve problems during engineering development. This paper presents a completely automated system with a Vehicle Data Recorder (VDR) installed in a vehicle that collects diagnostic and prognostic data for numerous subsystems throughout the entire vehicle with automated data processing, analysis, and reporting. A recent test program with this system collected data from over 32,000 drive cycles containing over two million records of data and automatically assessed the performance of thirty-eight subsystems as well as providing the necessary data for all subsystem failures that occurred during the testing.

Data based diagnostic methods have been used to predict failures by analyzing vehicle data compared to the normal performance of the entire fleet^{2,3}. This paper presents how a system is applied to simultaneously support both diagnostic and prognostic engineering methods. The system provides traditional reactive methods assisted by telematics to reliably provide useful data and expedite root cause analysis. The reactive process begins by acquiring data with a VDR when a pre-defined event is detected. This data is then automatically downloaded to a back office server where it is processed and Engineering is automatically notified. The application of statistical process control theory to on-board diagnostics is used to assess the robustness of individual diagnostics and

**Documents**

Document Sharing Hub

subsystems. Every subsystem metric is continuously evaluated and recorded by the VDR. This data is then analyzed and the robustness assessed by comparing the diagnostic threshold to the mean and standard deviation of the test results. The diagnostic and prognostic data are available via a web-based application featuring asset management, data analysis tools, automated issue management and reporting.

This system depends on reliable data acquisition by a VDR. However, VDRs present their own set of challenges in providing quality data reliably when deployed in remote testing environments. These challenges include but are not limited to: significant time to get data to Engineering due to manual handling of data files and having to convert and/or run analysis scripts on files. There is also no reliable way to ensure the VDR data storage isn't full or that it records the correct addresses given the prospect of module re-flashes in the test fleet. A reliable method for providing useful data to Engineering in a timely manner can be accomplished by combining VDRs with telematics and information technology. By automating the data acquisition, transfer, processing, and monitoring the VDR for performance, Engineering will be immediately notified of any issues and be able to begin to solve problems with useful vehicle data. This can be accomplished with a VDR software architecture as shown in [Figure 1](#), which features a VDR Management software layer to ensure VDR performance is optimized. Critical components in the VDR Management layer are the DAQ Settings Management and the VDR Diagnostics System. These two elements ensure that the correct vehicle data is being recorded and that the VDR system is functioning robustly.

INDUSTRY OVERVIEW

Designing a robust powertrain system is difficult due to its non-linear complexity, multitude of tradeoffs, and the need to satisfy both customer and regulatory requirements. The Heavy Duty Industry is undergoing unprecedented change due to significant increases in regulation for tailpipe emissions, [Figure 2](#). Fuel economy is also important, as the price of fuel is critical to vehicle owners. Solutions for improved fuel economy and emissions are, minimally, independent of each other and, in some cases, can be counter-productive.

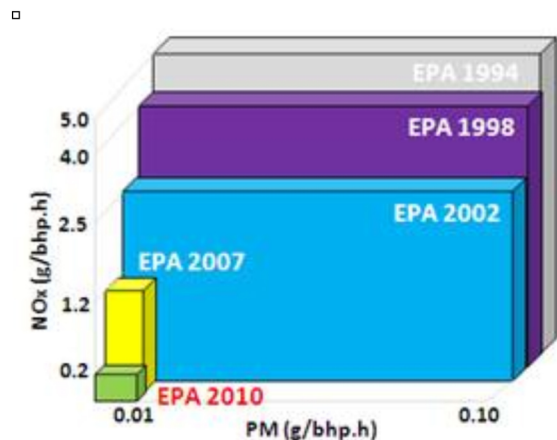


Figure 2. Heavy Duty Emissions Standards⁴

All of these solutions are required to be diagnosed via On-Board Diagnostics (OBD) as mandated by the California Air Resources Board (CARB) and the Environmental Protection Agency (EPA). This requires the 'Check Engine Light' or 'Malfunction Indicator Light' (MIL) be illuminated for any hardware failure before exceeding a multiple of the emissions standard, [Table 1](#). Failure to do so may result in a regulation compliance problem, that can result in fines and *recall* for the affected vehicle line. Complicating the task is the fact that a company cannot afford to turn on the MIL when a malfunction is not present as this action creates unnecessary warranty expense. Dissatisfied customers who typically will come back to the dealership multiple times as no hardware issue is found often result. Light Duty U.S. OEMs and Parts Suppliers are spending more than \$13 Billion on warranty annually, [Figure 3](#). Despite numerous Quality programs by these companies, warranty costs remain the same on a volume-adjusted basis, as reactive approaches cannot keep up with the increasing complexity of vehicles, [Figure 4](#).

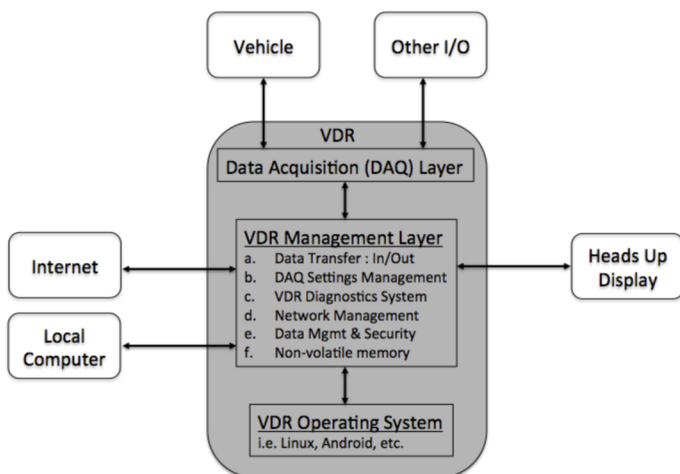


Figure 1. VDR Software Architecture

Table 1. OBD Threshold and Phase In Plan⁵

□ **HD-OBD Phase In Requirements (CARG 1971.1, GVWR > 14,000 lb)**

	2010	2013	2014
Emissions Threshold	2.5x Std	2.0x Std	2.0x Std
Application	Lead Engine of Lead Family	Lead Engine of All Families	All Engines of All Families
Deficiencies	Unlimited	Fineable, limited	Fineable, limited

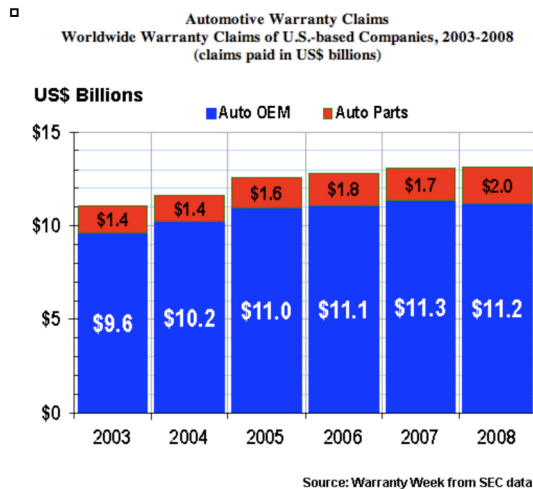


Figure 3. U.S. Based Light Duty Automotive Companies
Warranty Expenses⁶

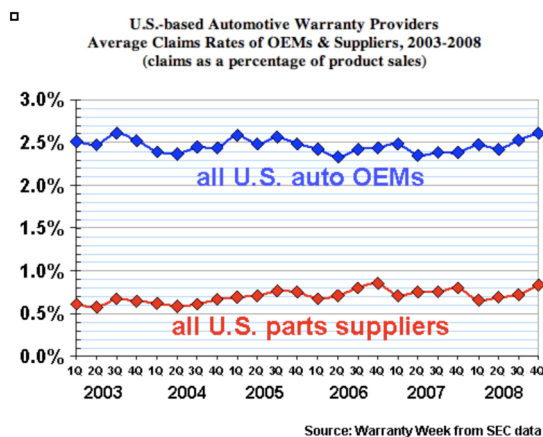


Figure 4. U.S. Based Light Duty Automotive Companies
Warranty Expenses⁶

The Heavy Duty Transportation Industry is having warranty challenges as well with the onset of increased regulations as new NMHC regulations were implemented in 2004, Nitrous Oxide (NOx) emissions regulations were made more stringent in 2007, and OBD phase-in started in 2010 and continues to 100% compliance by 2016. [Figure 5](#) shows the

warranty performance of a competing Diesel Engine manufacturer during this period. Each one of these regulation changes has resulted in increased warranty. Per J.D. Power and Associates⁷, the problem rate for Heavy Duty vehicles in 2010 is twice as high as that in 2004 and that over 50% of owners have experienced some type of problem. True development process innovation is required to improve quality and reduce warranty in the Heavy Duty Industry while still complying with OBD regulations. The Light Duty Transportation Industry adopted OBDII regulations beginning in 1996. A study by CARB⁸, showed that OBDII vehicles failed the state Smog test about twice as often for OBDII detected issues than for the previously legislated OBDI regulations. The study also showed that vehicles with OBDII that were 10 years old had a failure rate of approximately 10%. The cost to repair failed components that have been identified by the OBDII system are the responsibility of the manufacturer. It is reasonable to assume that the Heavy Duty Industry will see an increase in warranty costs due to the introduction of OBDII as was seen in the Light Duty Industry.

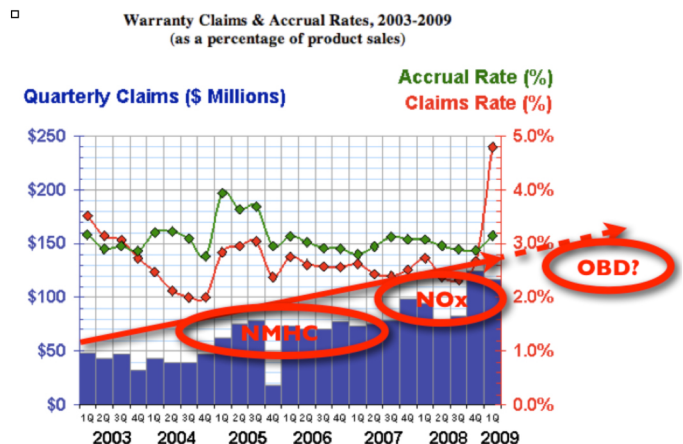


Figure 5. Warranty for a Competing Diesel Engine
Manufacturer⁶

EXPEDITED ROOT CAUSE ANALYSIS

Manufacturers typically test vehicles during development and consider no identified failures a “pass”. Engineering feedback is often limited to contact with a fleet supervisor when the system fails. However, no information is known other than the fact that a failure occurred. The engineer is now forced to try to reproduce the issue in order to collect the data necessary to solve the problem and has no idea if this issue was a ‘one off’ or is indicative of a potentially major problem. Control-Tec and Navistar jointly implemented an automated validation system utilizing a VDR that automatically downloaded vehicle data from an existing test