TELEMETRY DATA: A RESOURCE FOR AUTOMOTIVE SAFETY INSIGHTS

July 2023

A paper jointly produced by The MITRE Corporation and General Motors

Introduction and Call to Action

Vehicle telemetry data—that is, data generated by a motor vehicle and sent to an off-board computer system—can be a resource for advancing automotive safety. But using these data most effectively will require collaboration among automakers, other members of the automotive community, and state and federal governments, among others. This activity must also take into consideration an understanding of both the associated benefits and challenges, including the critical need to protect user privacy. General Motors (GM) and the MITRE Corporation—a partner to the U.S. Department of Transportation on a variety of transportation safety initiatives—have teamed up to help advance the use of telemetry data in an effective and appropriate manner.

Telemetry data can include information on safety system activations, vehicle diagnostic trouble codes (DTCs), and module sensing data. These data can help to identify and address potential emerging safety issues. However, a challenge lies in continuing to develop the collection, processing, and analytical capabilities that will allow the global transportation community—including automakers, fleet operators, city planners, federal and state governments, and transportation safety researchers—to fully leverage the safety insights that telemetry data can provide.

Government entities such as the National Highway Traffic Safety Administration (NHTSA) and institutions performing automotive safety research could obtain additional awareness of systemic safety issues and emerging safety hazards using telemetry data analysis. This increased awareness can help promote a safer transportation system.

A "whole of community" approach that brings the strengths of all community members to the table can improve safety for everyone. For example, the Partnership for Analytics Research in Traffic Safety (PARTS) collects data across multiple automakers in the interest of improving automotive safety. Through PARTS, which MITRE operates as an independent third party, automakers and NHTSA share safety-related data for collaborative analysis to gain real-world insights into the safety benefits and opportunities of advanced driver assistance systems (ADAS) and active safety systems.

The automotive safety community now has an opportunity to invest more in the incorporation of telemetry data into their analytics and research. This could allow a wider array of stakeholders to look across data sets to identify, communicate, and help resolve common issues. As an example, telemetry data collected during the activation of a driver assistance system such as automatic emergency braking may indicate that the feature is less effective in certain weather conditions. A broad, data-driven review of these types of events may help identify a potential emerging safety concern and point toward solutions to improve performance across many different vehicle makes and models.

Telemetry data can also enable a deeper perspective on crash and near-miss data.

GM and MITRE are therefore working together to better understand additional uses for telemetry data, how best to conduct meaningful analyses, and how individual automakers' efforts can support broader efforts to tap the potential of telemetry data to enhance safety industrywide.

GM and MITRE have taken steps to build, standardize, and enhance vehicle telemetry analytical capabilities—not just to improve the safety of GM vehicles, but to improve the depth of analysis possible for future industry and government collaborative efforts in the interest of safety.

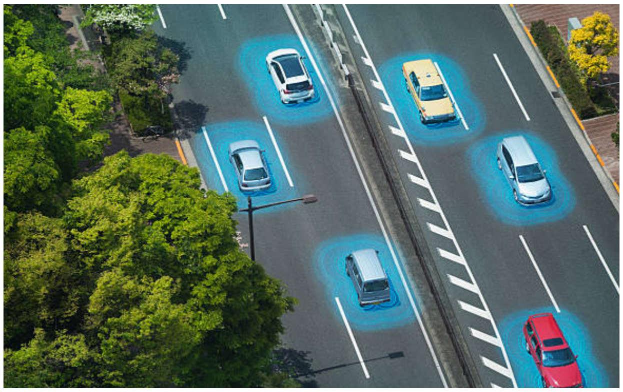
GM AND MITRE CALL ON THE AUTOMOTIVE SAFETY COMMUNITY TO JOIN US IN THINKING NOW ABOUT HOW WE MIGHT MAKE SUCH TELEMETRY DATA SHARING POSSIBLE—IN A WAY THAT PROTECTS CONFIDENTIALITY, PRIVACY, AND COMPETITIVE ADVANTAGE WHILE PROMOTING OVERALL AUTOMOTIVE SAFETY.

The Existing Data Foundation

Historically, the automotive community has relied heavily on publicly available crash data for safety research. NHTSA provides access to several national crash databases, including the [Crash Report Sampling System](#) (CRSS) and [Crash Investigation Sampling System](#) (CISS). These databases contain valuable information, such as driver behavior observations, the vehicle's estimated change in speed during a crash (delta-velocity), whether airbags were deployed, and the strike location on the vehicle itself. This data can be used for targeted research—such as on severe impact crashes involving specific vehicle segments—to gain insights into how active and passive safety systems are performing in the field and to help prioritize system and design improvements to improve safety.

NHTSA also manages the [Fatality Analysis Reporting System](#) (FARS), a nationwide census providing yearly data regarding fatal injuries suffered in motor vehicle accidents. Researchers have used this information to support the development, implementation, and assessment of highway safety initiatives aimed at reducing high-severity crashes. Industry has used this database for safety improvement as well. For instance, after databases like FARS indicated that rollovers were a significant factor in many automotive fatalities, manufacturers introduced electronic stability control into their vehicles to help prevent rollovers and introduced structural changes to protect vehicle occupants if a rollover did occur. The result was a dramatic decrease in rollover frequency and therefore fewer fatalities from vehicle rollover events.

However, current databases are limited in how they capture the vehicle's perspective of what happened before/during a crash and have known limitations due to biases in what occupants are willing to share with police or crash investigators. They also do not capture what happened in low-severity or near-miss situations, information that could generate insights into how effective certain safety solutions were in mitigating or preventing an accident: Did the automatic emergency braking system engage, preventing a crash? Did lane-keep assist software and blind-spot sensors prevent a driver from sideswiping a vehicle in the adjacent lane? Were ADAS features enabled and/or engaged in the moments leading up to a crash, and did the vehicle respond as expected? To answer these questions, more vehicle telemetry data should be collected and standardized.



DID THE AUTOMATIC EMERGENCY BRAKING SYSTEM ENGAGE, PREVENTING A CRASH? DID LANE-KEEP ASSIST SOFTWARE AND BLIND-SPOT SENSORS PREVENT A DRIVER FROM SIDESWIPING A VEHICLE IN THE ADJACENT LANE? WERE ADAS FEATURES ENABLED AND/OR ENGAGED IN THE MOMENTS LEADING UP TO A CRASH, AND DID THE VEHICLE RESPOND AS EXPECTED?

Proactive and Predictive Research Using Telemetry Analytics

Historically, incorporating telemetry data into traditional crash data collection strategies has been challenging given the limited data that is available at the time of a crash event. As vehicle systems for collecting and transmitting data are rapidly evolving, the ability to generate a vehicle-based view of a crash—or near-miss—can become a reality. Vehicles that are connected to a communications network, such as OnStar for GM vehicles, have the potential to transmit more data around the time of a crash than has been possible in the past. When a vehicle is involved in a crash, traditional data like that collected in CISS, CRSS, and FARS could be augmented with this additional telemetry data.

Elements such as the delta-velocity of the vehicle, the primary direction of force, seat belt status, and airbag deployment can help quickly identify not just the occurrence of a crash, but also help determine its severity.

With ADAS now standard equipment on many vehicles, and even more driver assistance features on the horizon, increasing amounts of related safety feature telemetry data can be collected. In addition to ADAS information, vehicles can collect other contextual data at the time of crash events or at specific time intervals: DTCs, vehicle system states such as engine speed or ambient air temperature, vehicle use information such as distance traveled and fuel usage, and driver behavior information such as seatbelt usage and gaze detection information, if available. Each of these data types, and the frequency of data collection, has a role to play in safety research, especially when integrated across both crash and near-miss events.

As recent PARTS and Insurance Institute for Highway Safety research has shown, ADAS and other automated features can make travel safer by

reducing the volume and severity of crashes. This improvement is good for the overall system, but the reduction in crash rates necessitates that safety researchers focus on risk factors upstream of the crash itself. The change in vehicle technology and improved collision avoidance performance provides an opportunity for original equipment manufacturers (OEM) to capture more telemetry data to better understand the circumstances of near-misses and how the vehicle's systems may have prevented, or contributed to, a crash. OEMs can then use this information to improve vehicle safety performance.

MITRE and GM see great value in collecting data from safety systems that show how they're performing on the road. That information helps inform engineering strategies to improve existing features as well as decisions about how to prioritize the development of new safety systems. Beyond these significant benefits for a single manufacturer, the targeted collection of telemetry data can enable more collaborative safety work with other manufacturers, government agencies, and safety research organizations.

GM and MITRE Team Up to Enhance Telemetry Analytics

MITRE and GM have partnered to evaluate and enhance the capability to collect, standardize, and analyze telemetry data for the improvement of safety.

GM and MITRE understand that the work to tap the power of telemetry data begins at the automaker level. GM has begun the work to integrate telemetry data into its safety research. For example, GM is collecting and fusing telemetry data with other vehicle data to look at issues in the field that could lead to safety improvements. This type of research can also be used to inform safety field action decisions.

As part of the effort to expand the use of telemetry data for safety research, GM and MITRE have worked together to improve existing telemetry data management strategies, implement tools to organize and normalize system state information from vehicle telemetry, and evaluate active safety system data around the time of a crash or near-miss.

Challenge: Managing Telemetry Data

We learned that data collected from vehicle diagnostics and associated vehicle system states can help identify patterns prior to the performance degradation of a specific subsystem. For example, in a typical forensic investigation, a researcher may look for specific vehicle history or a recurrence of a system issue across many vehicles. In some cases, issues later diagnosed by vehicle technicians are preceded by a pattern of vehicle DTCs during on-road vehicle operation. However, DTC activations occur for a variety of reasons, many of which are unrelated to safety performance, so it can be challenging to find a safety signal among the noise. A key challenge is the sheer magnitude of the available telemetry data. In some cases, there may simply be too much raw data to review on a practical basis. Standardized mechanisms for identifying the most meaningful data for safety/quality purposes may help in performing such evaluations. In addition, adapting the design of data archives could enable more efficient responses to analyst queries, help analysts select high-quality study samples, and help analysts quickly assess relevant content. The necessary data elements vary based on the scope of the issue being investigated and the vehicle systems involved. OEMs can use these use cases to re-evaluate the scope and the method of data capture for certain vehicle systems to better enable safety studies.

Additionally, the variety of streaming vehicle messages can create challenges for correctly decoding and interpreting the data. Automobile manufacturers offer multiple vehicle models, update the equipment on those models from year to year, and incorporate many subsystems managed by multiple engineering teams. Beyond capturing the equipment and capabilities on different models/years and making sense of the data from that equipment, adjustments are often being made to these systems. From one year to the next, the physical equipment or the triggering logic used on the vehicle's systems could change. For instance, engineers may change the thresholds for a specific DTC activation, but if that information is not captured in the metadata, it could cause the appearance of a sudden increase or decrease in system performance without any substantive change to the vehicle itself. Like hardware and software, calibrations can even change within a

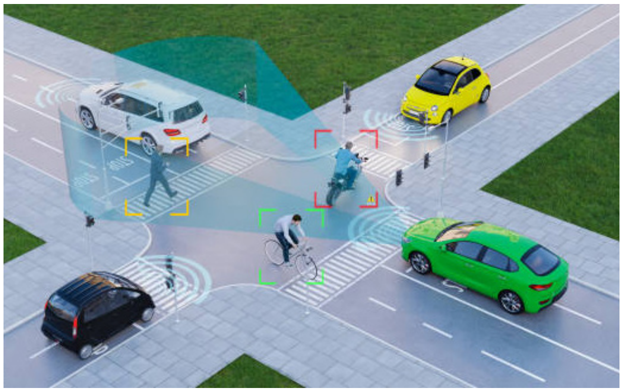
single model/model year for many reasons. To analyze potential trends, there needs to be a way to track these changes and updates so that researchers can make sense of the data.

MITRE and GM worked in partnership to generate a series of data flow templates for streamlining the extraction, normalization, and visualization of diagnostic telemetry data to support GM data analysts. These templates provided automated data quality filters for common issues and helped account for some of the typical variations across model and model year. We also identified priorities for further improving data quality.

Challenge: Finding Signal in the Noise

Another major challenge for using telemetry data for safety risk analysis is filtering out data "noise" from a potential "signal." Modern data science and statistical techniques can be applied to these diagnostic data sets to help make that distinction.

MITRE data scientists and GM telemetry experts worked together to take labeled maintenance records for a specific system fault and develop data models with the goal of finding predictive patterns of behaviors prior to a fault. This method of prognostic detection acts as a supplement to traditional forensic research, where the researchers may understand the specifics of a single event but need more tools to expand the scope of a study to other vehicles that might be at an elevated risk.



There will always be a need to review specific system faults and deep dive into specific vehicle safety analysis. Using modern data science approaches to identify trends and correlated factors can help prioritize safety research and provide broader context for forensic analysis.

Challenge: Leveraging Time Series Data from Near-Misses

In addition to this exploration of diagnostic telemetry data to assess risk, it is important to assess vehicle performance when an ADAS feature activates. ADAS features rely on external sensors to provide support to the driver and control systems such as steering and braking to react to threats. Telemetry data from these events can be used to validate vehicle performance in identifying threats proactively and responding effectively. For example, these data can be used to compare near-crash scenarios that match ADAS test scenarios to variations on those scenarios seen in the field, allowing additional insight into the robustness of the design.

MITRE and GM worked together to develop a prototype tool to review vehicle performance when automatic emergency braking was engaged. By enhancing GM's ability to capture, process, and analyze vehicle telemetry data during ADAS activations, tools such as this allow GM analysts to better identify near-miss crash patterns and advance vehicle safety.

Proposed Actions for Automakers and Government

Industry and government both have critical roles to play in realizing safety benefits from telemetry data. Each automaker must master the complex challenge of capturing and analyzing its own telemetry data to gain safety insights from fleets in the field to improve performance of new technologies and future vehicles. Further, by standardizing proactive and predictive safety data analysis processes, automakers can help not only their own organizations, but also contribute to collaborative research by participating in data-sharing partnerships that leverage vehicle telemetry data.

To realize the full potential benefit of telemetry data, it will be imperative that government and industry work together to facilitate data sharing. This will position the automotive community to make far greater impact by understanding vehicle performance and crash outcomes. As an example, if a particular roadway interferes with safety feature performance, this can be addressed as a whole community issue rather than being assumed to be one OEM's or infrastructure owner's particular issue. Participation in programs such as PARTS, which uses partners' combined data to generate safety insights that individual organizations cannot achieve by themselves, may be one answer to this challenge.

The use of modern data management and data science techniques to sift through telemetry data only becomes more critical as vehicle safety systems become more complex and the volume of data collected grows exponentially. Now is the time to prepare.

About MITRE

MITRE's mission-driven teams are dedicated to solving problems for a safer world. Through our public-private partnerships and federally funded R&D centers, we work across government and in partnership with industry to tackle challenges to the safety, stability, and well-being of our nation.

General Motors

General Motors (NYSE:GM) is a global company focused on advancing an all-electric future that is inclusive and accessible to all. At the heart of this strategy is the Ultium battery platform, which powers everything from mass-market to high-performance vehicles. General Motors, its subsidiaries and its joint venture entities sell vehicles under the Chevrolet, Buick, GMC, Cadillac, Baojun and Wuling brands. More information on the company and its subsidiaries, including OnStar, a global leader in safety services and connected vehicle technology, can be found at https://www.gm.com.

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