Progress Report

DTNH22–13–H–00433

October 1, 2016 through
September 30, 2017

2017

This report describes the progress made in a cooperative research program, known as the Driver Alcohol Detection System for Safety (DADSS), which is exploring the feasibility, the potential benefits of, and the public policy challenges associated with a more widespread use of non–invasive technology to prevent alcohol–impaired driving. This report includes a general accounting for the use of Federal funds obligated or expended in Fiscal Year (FY) 2017 in carrying out this effort.

In–Vehicle Alcohol Detection Research

Executive Summary

Since the beginning of the cooperative research partnership between the National Highway Traffic Safety Administration (NHTSA) and the Automotive Coalition for Traffic Safety (ACTS) in 2008, the Driver Alcohol Detection System for Safety (DADSS) Program has made great strides forward in the development of in-vehicle technologies that will prevent impaired drivers from driving their vehicles. Exploratory research in Phases I and II established the feasibility of two sensor approaches, breath- and touch-based, for in-vehicle use. In Phase III, the sensors became increasingly refined, in terms of both hardware and software, as the Program strived to meet the very high standards required for unobtrusive and reliable alcohol measurement. An integral part of this research effort includes numerous parallel research programs currently underway, which made significant progress in the fiscal year ending September 30, 2017.

The establishment of stringent performance standards for accuracy and precision, the likes of which have not before been attempted in alcohol measurement, has necessitated the development of innovative approaches that will verify the technology is indeed meeting these elevated standards. Specifically, calibration processes, materials, methodologies, and instrumentation have been the subject of extensive cutting-edge research to enable the requisite testing to ensure that the DADSS technologies meet and exceed these specifications. Research vehicles are being readied for Field Operational Testing (FOT) equipped with the latest versions of the sensors seamlessly integrated within the vehicle interiors. Instrumentation packages also have been developed that will provide a myriad of data on sensor performance under challenging real-world driving conditions. Along with determining whether the DADSS sensors are working as anticipated, the FOT data-collection effort will allow the identification of areas for system improvement. A comprehensive program of human subject research is being carried out, starting with the laboratory environment where better control of conditions can be exerted, and in the vehicle where the sensors can be tested in the environment in which they will be used. This research will establish that alcohol measurements made with diluted breath and tissue samples are comparable to the well-accepted standards of venous blood and deep-lung air widely used in traffic law enforcement. At the same time, media coverage and consumer sentiments are being monitored in anticipation of a future launch of the technology. These efforts will be ramped up once the technology is available for public scrutiny because the driving public must support the DADSS technology in order to see it widely implemented.

The surface transportation reauthorization enacted in 2012, Moving Ahead for Progress in the 21st Century (MAP–21), specifically authorized research for the DADSS Program.[1] The statutorily authorized research has been implemented through a Cooperative Agreement between NHTSA and ACTS, which was agreed to in October 2013 (the "2013 Cooperative Agreement"). This report describes the progress made under the DADSS Program during fiscal year 2017.

During the fiscal year ending September 30, 2017, the following accomplishments were realized:

- Breath–Based DADSS Subsystem Research
    - Completed the design, development, and manufacturing of the next Generation DADSS sensor, Gen. 3.1.
        - Sensor resolution was improved by a factor of three for alcohol and a factor of four for carbon dioxide measurements.
        - Investigation of a new detector technology with the potential to increase resolution three to eight times was undertaken.
    - The Gen 3.1 sensor has undergone rigorous verification and validation testing aimed at simulating a sensor life of 15 years per the DADSS Performance Specifications. Testing was largely successful, but there were a few areas in which development is needed for product certification. These are discussed on page 14.
    - Installation work has been completed for sensor integration in research vehicles for FOTs. Mechanical design work was performed along with the development of an on-board communication interface.
    - The DADSS laboratory has accepted delivery of 116 Gen 3.1 sensors for DADSS laboratory testing and integration into research vehicles.
    - The DADSS laboratory has received 15 Chevrolet Malibu vehicles, model year 2017, from General Motors (GM) that are being prepped for integration of breath-based sensors.
    - Sensor calibration procedures for breath-based sensors have been updated to align with the latest technology and procedures used in the DADSS laboratory.

- Touch-Based DADSS Subsystem Research
    - An external review of the development team, technology validation, and technical approach was successfully completed.

[1] See section 403(h) of title 23 of the United States Code as amended by Public Law 112-141, December 4, 2015.

  - The source of the laser fluctuations in the Gen 4 sensor was pinpointed as the result of issues with the reference channel, and steps were taken to redesign the optical subsystems.
  - A new optical touch pad system design was completed.
  - Hardware updates demonstrated improved optical performance in laboratory testing.
  - Designed and built new electronic subsystems for the Gen 5 sensor.
  - Conducted preliminary testing of the new laser (STINGRAY) packages.
  - Validated the base performance of the novel laser architecture enabling the Gen 5 sensors for FY2018.
  - Completed the new laser package intended for FY19 Gen 6 sensors.
  - Improvements were made to the surrogate tissue samples for greater reliability and precision.
  - A new in-vitro sample chamber for laboratory testing of the sensors was designed, built, and tested.
  - The first anti-circumvention prototype was built and tested.

- Standard Calibration Devices Research
  - Breath-Based Sample Reference Materials (SRMs), both dry and humidified gases, achieved precision targets that were four times better than the DADSS specification (the calibration device target is 0.000075% Breath alcohol concentration versus 0.0003% for the sensor).
  - The humidified gas production and measurement system has been optimized to a precision measurement of 0.000056% breath alcohol concentration using the state-of-the-art MKS Fourier Transform Infrared (FTIR) spectroscopy instrumentation.
  - Improvements were made to the gas delivery systems using pulsed dry and humidified gases to achieve a steady flow into the sensors for maximum performance. These new procedures will allow simultaneous testing of multiple sensors to improve efficiency.
  - Gen. 3.0 breath-based sensors were comprehensively tested to verify system performance. The new approach passed the gases through the FTIR to confirm the precision of the gas sample before entering the sensor. Gen 3.1 sensors have been received and will undergo testing soon.
  - Using the latest instrumentation, tissue solutions have been comprehensively tested using different iterations of experimental set ups and measurement methods. The calibration curves that were generated confirmed significant precision.
  - The DADSS laboratory collaborated with SenseAir, the manufacturers of the sensors, to ensure that they are now aligned with the DADSS laboratory in their use of the MKS FTIR.

- Human subject testing
    - A human subject testing paradigm has been implemented that allows the simultaneous collection of blood, tissue, and breath samples. This is important because it allows a direct comparison of the alcohol in blood, breath, and tissue.
    - A unique protocol was developed that allows the study of three participants at a time and maintains quality of measurement.
    - Three versions of the breath sensor and two versions of the touch sensor have been evaluated.
    - Substantial progress in measuring the alcohol absorption and elimination curves across all of the scenarios identified by a comprehensive literature search with a total of 78 subjects (4,500 blood samples).
    - Results of testing to date indicate that the scenarios have an effect on the alcohol pharmacokinetic curves. For example, exercise causes a rapid increase in the rate of absorption of alcohol, dispelling the myth that exercise can "burn off" alcohol. Also, how much you eat while drinking can affect the rate of absorption, with a full meal slowing the rate of alcohol absorption more than a snack.
    - The "last call" drink consumed at the end of a drinking session was shown to not only cause alcohol measurements to spike, but also increase blood and breath alcohol even more than a similar drink consumed at the beginning.
    - Across the range of scenarios, a solid linear relationship between blood, breath- and tissue-based alcohol concentrations has been established. This indicates that the measurements produced by the various generations of breath-based and touch-based prototypes is consistent, reproducible, and correlates very well with the gold-standard method of measuring alcohol in the body—blood via gas chromatography.

- Pilot Field Operational Trials (PFOT).
    - Development of the PFOT Test Plan for the observation and use of the DADSS sensors in a real-world driving environment. This includes the identification of regional sites that explore varying environmental conditions.
    - Development of operational and system requirements for each regional site for day-to-day operations.
    - Development of system and study requirements as derived by the PFOT test plan and power analysis performed to derive the required number of test participants.
    - Development of specifications as derived by the operational and system requirements.
    - Successful completion of a preliminary design review for the Data Acquisition System (DAS).

- A number of supporting design documents for the PFOT trials have been successfully completed, including Data Flow, Software Architecture and Design, DAS hardware and software analyses and analyses needs, and the roles and responsibilities of the PFOT research team.

Introduction

Decades of research, focusing mainly on modifying driver behavior through strong laws and enforcement, has identified ways in which alcohol-impaired driving can be reduced.[2] Significant progress was made based on these tried-and-true approaches through the 1980s, 1990s, and early 2000s. However, for the last few years, progress has halted; and after falling for many years, alcohol-impaired fatalities are now at their highest level since 2009 (NHTSA, 2017).[3] Currently, fatalities involving alcohol-impaired drivers remained at around 10,000 per year (i.e., fatalities involving a driver with a blood alcohol concentration (BAC) of 0.08 grams per deciliter (g/dL) or 0.08 percent or greater).

Due to the seemingly intractable nature of this problem, a clear need has been identified for a sustainable solution that no longer leaves the decision to drive impaired in the hands of an impaired driver. In 2008, a public/private partnership was begun between the National Highway Traffic Safety Administration (NHTSA) and the Automotive Coalition for Traffic Safety (ACTS[4]), to design an effective technological solution to end alcohol-impaired driving on U.S. roads.[5] The Insurance Institute for Highway Safety research has estimated that 6,973 deaths could have been prevented in 2015 if all drivers with BACs of 0.08 percent or higher were kept off the roads.[6]

This cooperative research partnership between NHTSA and ACTS, known as the Driver Alcohol Detection System for Safety (DADSS), has identified feasible technologies which could prevent alcohol-impaired driving through instantaneous measurement of

[2] Ferguson, S.A. 2012. Alcohol-impaired driving in the United States: Contributors to the problem and effective countermeasures. Traffic Injury Prevention, 427-41.
[3] National Highway Traffic Safety Administration. 2017. Traffic Safety Facts. Alcohol-Impaired Driving. DOT HS 8124450. Washington DC.
[4] ACTS is classified as a 501(c)(4) nonprofit corporation by the U.S. Internal Revenue Service. Funding for ACTS is provided by motor vehicle manufacturers, who make up its membership. ACTS' current members are: BMW Group, FCA US LLC, Ford Motor Company, General Motors Company, Honda Research & Development, Jaguar Land Rover, Mazda North America Operations, Hyundai America Technical Center Inc., Mercedes Benz USA, Mitsubishi Motors, Nissan North America, Inc., Porsche, Subaru of America, Inc., Toyota Motor Sales, U.S.A., Inc., Volkswagen of America, Inc., and Volvo Cars. These ACTS members account for the majority of new light vehicle sales in the U.S. market.
[5] ACTS members manufacture 99 percent of light vehicles sold in the U.S.
[6] Insurance Institute for Highway Safety. https://www.iihs.org/topics/alcohol-and-drugs

driver breath- or tissue-alcohol. The DADSS program is developing non–intrusive technologies that could prevent the vehicle from being driven when the device registers that the driver's blood alcohol concentration meets or exceeds the legal limit (currently at or above 0.08 percent).[7] The selected technological approaches are founded on a clear understanding of the processes by which alcohol is absorbed into the blood stream, distributed within the human body, and eliminated. Not only must the technologies quickly and accurately measure BAC, but the medium through which it is measured (e.g., breath, tissue, sweat) must provide a valid and reliable estimation of actual BAC or breath alcohol concentration (BrAC) levels.

After a thorough review of the literature and technical approaches during Phase I of the research, only two approaches held merit for quick and accurate measurement of driver BAC/BrAC. These were tissue spectrometry and distant, breath-based spectrometry systems. Tissue spectroscopy systems allow the estimation of BAC by measuring alcohol concentrations in tissue. This is achieved through detection of light absorption at a particular wavelength from a beam of near-infrared light reflected from within the subject's tissue. The breath-based approach is similar in that an infrared (IR) beam is used to analyze BrAC. Expired breath, mixed with the vehicle cabin air, is drawn into an optical cavity where an IR beam is used to analyze the alcohol concentration in the subject's exhaled breath.

The 2008 cooperative agreement between NHTSA and ACTS (covering Phases I and II of the research)[8] began with a comprehensive review of emerging and existing state–of–the–art technologies for alcohol detection in order to identify promising technologies that are capable of measuring BAC or breath-alcohol concentration (BrAC) in a vehicle environment. Under specific authorizations for the DADSS program in the Moving Ahead for Progress in the 21st Century (MAP-21) Act and the Fixing America's Surface Transportation (FAST) Act, additional research has continued under a new cooperate agreement (covering Phase III of the research).[9] Phase III involves continued research into the DADSS technology and test instruments as well as basic and applied research to understand human interaction with the DADSS sensors both physiologically and ergonomically, that is, how these technologies might operate in a vehicle environment. The culmination of this effort will be a device or devices that will allow a determination regarding whether the DADSS technologies can ultimately be commercialized. If it is

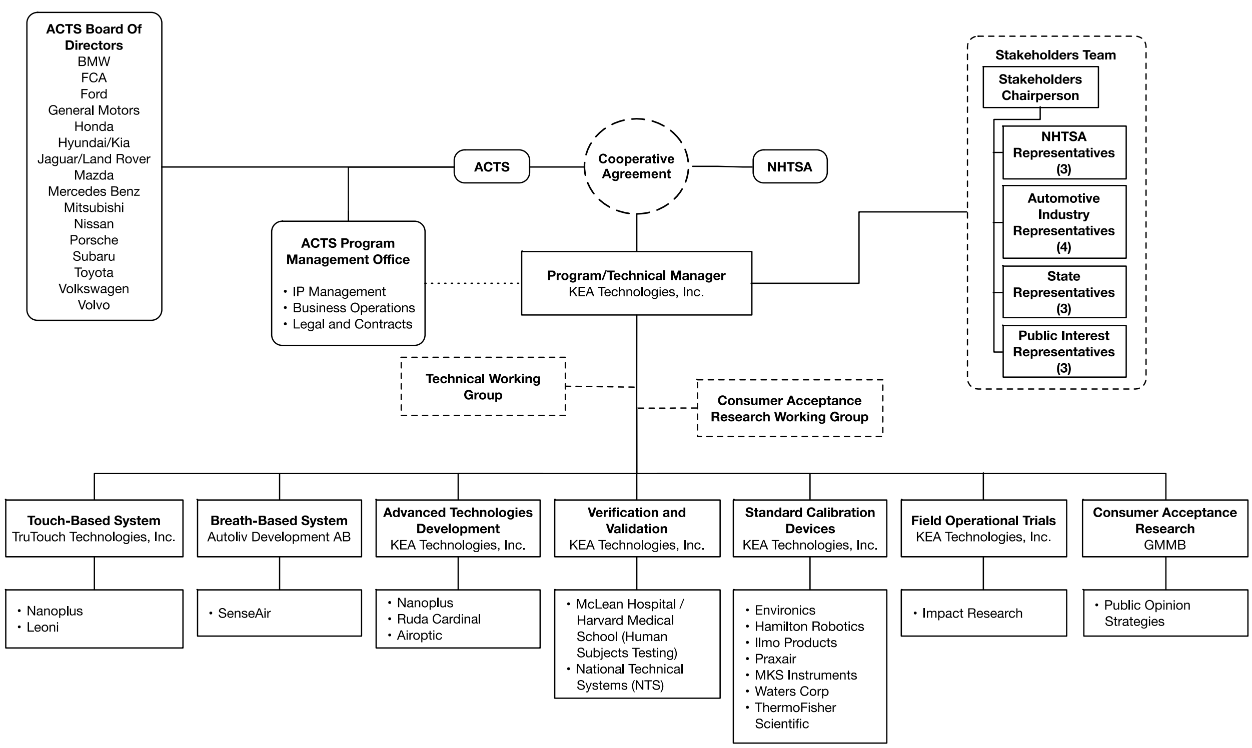
[7] From inception in 2008, the DADSS Research Project has been based on a BAC threshold of 0.08 percent or greater. The statutory language for the DADSS program similarly identifies this threshold. See section 403(h) of title 23 of the United States Code.
[8] Zaouk A. K, Willis, M., Traube, E., Strassburger, R. 2015. Driver Alcohol Detection System for Safety (DADSS) – A Status Update. Paper Number 15-0276. Proceedings of the 24th International Technical Conference on the Enhanced Safety of Vehicles.
[9] See section 403(h) of title 23 of the United States Code as last amended by Public Law 114-94, Dec. 4, 2015.

determined that one or more of these technologies can be commercialized, it is currently anticipated that the private sector will engage in future product development and integration into motor vehicles.

As required by the FAST Act,[10] the remainder of this report will discuss these research programs in more detail and the progress achieved towards these goals in FY 2017. This report also includes a general accounting for the use of Federal funds obligated or expended during this period.

DADSS Research Program Team

On January 20, 2017, NHTSA and ACTS amended the Cooperative Research Agreement to create a Stakeholders Team (Figure 1). The Stakeholder Team is an important new part of the DADSS effort that will provide critical input to the program on public policy, deployment, state law issues etc. The Stakeholder Team consists of up to fourteen members and consists of representatives from NHTSA, the automotive industry, participating state governments, and public interest groups.



[10] NHTSA is required to provide an annual report for in-vehicle alcohol detection device research that describes the progress made and includes an accounting of Federal funds obligated or expended. 23 U.S.C. § 403(h)(4).

Figure 1. **DADSS research program organization with stakeholders team**

Phased Research Plan with Technical Review Gates

From inception, the DADSS program has been structured to minimize risk by separating the research into phases with technical review gates between phases. The intent of Phase I was to research prototypes that could rapidly and accurately measure a driver's BAC non-intrusively. The prototypes constructed during this Phase (1st Generation) were designed to demonstrate the proof of concept prototypes. The prototypes did not attempt to address repeatability and reliability. Three prototypes were delivered and tested at the DADSS laboratory (Figure 2), which yielded promising results for two of the three technologies. Thus, at the conclusion of Phase I, it was determined that both touch– and breath–based technologies showed promise in meeting the DADSS Performance Specifications.

The Phase II effort, begun in late 2011, spanned two years and required technology providers to make significant improvements to device accuracy, precision, reliability, and speed of measurement. The effort also examined an extensive array of performance requirements common in the automotive industry over a wide range of environmental conditions. However, the devices' accuracy, precision, and speed of measurement will not be fully quantified until the completion of all required testing.

Figure 2. DADSS Research Laboratory

Phase III of the research will permit further refinement of the technology and test instruments as well as basic and applied research to understand human interaction with the sensors both physiologically and ergonomically. Phase III is focusing on optimizing and improving the DADSS sensors with the objective that the devices ultimately meet or exceed the DADSS Performance Specification. The goal of the research is to have a device or devices that will allow a determination to be made regarding whether the DADSS technologies can ultimately be commercialized. If it is determined that one or more of these technologies can be commercialized, it is currently anticipated that the private sector will engage in further product development and integration into motor vehicles.

DADSS Research Programs

The DADSS program of research and development began with the assumptions that, to be successful and acceptable to the driver, many of whom do not drink and drive, the technology must be seamless with the driving task. It must be speedy and unobtrusive, extremely reliable, and highly accurate and precise. To meet these challenging needs, performance specifications were developed at the outset that are unprecedented in the field of blood-alcohol measurement. These specifications, which are updated on an ongoing basis, provide the template for the research effort (the current version of which is set forth in the DADSS Performance Specifications).

Research is ongoing in Phase III to further the development of the two sensor subsystems. Progress is being made in meeting the rigorous performance specifications necessary to conduct driver alcohol measurements in a vehicle environment subject to a myriad of challenging conditions. The challenge for the breath-based system will be to meet the performance requirements while measuring diluted breath within the vehicle cabin. Thus, a significant component of the research is focused on understanding expired breath aerodynamics within the vehicle cabin and identifying effective locations for the sensors. For the touch-based system, challenges are associated with production of dedicated lasers that specifically target alcohol measurement, the packaging of these lasers within multi-laser packages, and delivery of the diffuse light source to the skin.

The development of the breath- and tissue-based in-vehicle sensors is the central focus of the DADSS research effort. However, the DADSS research program is multifaceted, with many programs of research and development being pursued simultaneously under the DADSS umbrella. The breadth of the research undertaken by the DADSS team necessitated the construction of a DADSS laboratory where in-house research is conducted by a team of highly-trained professionals with expertise in numerous disciplines. These additional research efforts are vital components to support and validate the approaches and technologies that are produced. As mentioned earlier, not only must the technology meet requirements to operate seamlessly with the vehicle start-up function, and be highly accurate and precise, often in extreme conditions of high elevation, cold, heat, and humidity, but as with other safety technologies, the systems must work reliably for the full operating life of the vehicle. The accuracy and precision of the alcohol measurements must be confirmed not only in the laboratory using human subjects and breath and tissue surrogates but also with human subjects in conditions that replicate those likely to be experienced in the real world. When the technologies have successfully met all these exacting criteria, the driving public must be supportive of this optional technology and be willing to purchase it for their vehicle. To that end, a separate effort was launched to engage the driving public in discussions about the technologies so that their feedback could be incorporated into the DADSS specifications as early as possible in the development cycle. When the technology is authenticated for real-world use, the driving public must be on board with this concept in order for it to be widely implemented.

DADSS Subsystems Technological Research

Two approaches are being pursued that have considerable promise in measuring driver BAC/BrAC non-invasively within the time and accuracy constraints established**:** Distant/Offset Spectrometry, a breath-based approach, and Tissue Spectrometry, a touch-based approach. The identification of these promising technologies was the subject of a Request for Information from companies with expertise in these areas during Phase I, followed by a Request for Proposals for those technologies considered feasible. The outcome was two successful proof-of-principle prototype devices—one breath-based and one tissue-based.

SenseAir AB Breath–Based Subsystem

The breath-based approach uses sensors to measure the concentrations of alcohol and carbon dioxide in the breath simultaneously. The known quantity of carbon dioxide in the human breath is an indicator of the degree of dilution of the alcohol concentration in expired air. Diluted breath is drawn into the sensor by a fan, which directs infrared light beams on the breath sample and analyzes the wavelengths returned for both alcohol and carbon dioxide. Breath alcohol concentration is then quickly and accurately calculated.

The ultimate goal of the DADSS sensors is to measure breath alcohol within the vehicle cabin without direct input from the driver, i.e., passively. The challenge with the breath-based system will be to meet the performance requirements while measuring highly diluted breath. Thus, a significant component of the research is focused on understanding expired breath aerodynamics within the vehicle cabin and identifying effective locations for the sensors. The breath-based sensor has been updated in Phase III with the goal of improving this capability (see Figure 3, Evolution of breath-based DADSS sensor). This latest version underwent a complete redesign to increase resolution for passive sensing, reduce the overall size, and obtain improved performance over the full temperature range of -40°C to +85°C as specified by the DADSS Performance Specifications. A major improvement of this 3rd generation sensor was the optical module configuration in which ethanol detection takes place over the full length of the sensor, whereas carbon dioxide is detected crosswise. With this configuration, there is no systematic timing difference between the two signals, thus enabling the possibility of passive in-vehicle sensing.

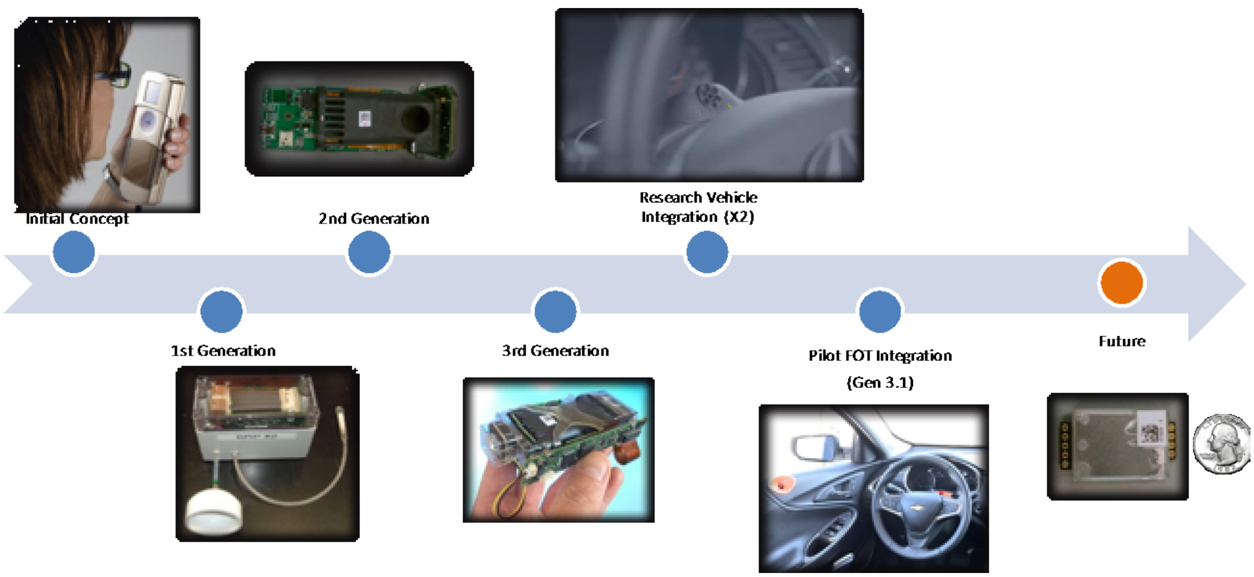


Figure 3. Evolution of breath-based DADSS sensor

After comprehensive research that investigated optimal sensor placement in numerous locations within the vehicle, the sensor was adapted for installation in the DADSS research vehicles in two different positions: above the steering column and in the driver's door panel. These positions improved analysis of the impact of cabin air flow and the driver's position on alcohol measurements as well as optimized performance. Research is ongoing of real-world testing with HVAC, so final decisions on sensor placement have not been made. The current implementation of the sensors requires a directed breath sample, although work is currently focused on implementing algorithm updates to support a "sniffer function" that will provide the capability for the sensor to passively detect the presence of alcohol.

Significant progress has been made in FY2017 on a number of fronts. Improvements have been made to the breath-based sensor's (now Gen 3.1) measurement resolution and commercial readiness for the vehicle environment, in-vehicle aerodynamics, and calibration methodologies.

- The sensor has undergone both hardware and software design changes that have improved the resolution of core sensor performance for passive operation. The alcohol channel resolution was increased by a factor of three, and resolution of the carbon dioxide channel by a factor of four. These improvements are critical for passive sensing to be successful. Together, these improvements resulted in a new breath-based sensor, termed Gen. 3.1. Studies also were undertaken into alternate detector technologies that might be capable of improving sensor resolution even further in the region of 3-8 times.

- The Gen. 3.1 sensor has undergone rigorous environmental testing to represent a simulated sensor life of 15 years. The sensor passed most of the tests, but occasional failure of individual sensors occurred in EMI shielding and functioning at the outer extremes of temperature requirements (e.g., -40C). Such failures indicated areas where further development is needed for production readiness. It should be noted that precision and accuracy requirements have not yet been met by the sensors.
- Simulations were undertaken to estimate breath dilution levels within the vehicle using various climate control settings with the sensor on the steering column. The simulations were also verified using in-vehicle tests. Both methods showed that dilutions in the order of 25-500 are to be expected when in passive detection mode, suggesting additional sensor resolution would be needed.
- In-vehicle sensor placement for the planned Field Operational Trials (FOT) using a Chevrolet Malibu has been completed. Not only have the sensors been integrated in four locations (both driver and passenger-side for experimental purposes) but work has been completed for the on-board communication interface. In total, 116 Gen. 3.1 sensors have been delivered to the DADSS laboratory for testing and to equip the FOT vehicles.
- The DADSS laboratory has received 15 2017 Chevrolet Malibu's from General Motors, which are being prepped for the integration of breath-based sensors.
- Research has been underway to explore in-vehicle video recordings as an assistive tool in determining the driver's breathing pattern and direction of exhalation. This technique is being investigated as a tool to ensure the source of the breath is the driver's and to identify potential circumvention maneuvers by the intoxicated driver.
- Until recently, the DADSS and the SenseAir laboratories were using different methodologies for sensor and SCD calibration. During FY 2017, both the sensor production facility and the testing laboratories in Sweden have adopted the latest MKS Fourier Transform Infrared (FTIR) spectroscopy instrument (see Standard Calibration Devices on page 17 for more details) identified by the DADSS Program. This alignment is an essential step to ensure that the SenseAir and DADSS laboratories are on the same page in reaching the DADSS goals for accuracy and precision.

TruTouch Touch-Based Subsystem

The tissue-based approach analyzes alcohol found in the driver's fingertip tissue (or more specifically, the blood alcohol concentration detected in the capillaries). The driver touches an optical module and a near-infrared light shines on the driver's skin, similar to a low power flashlight, which propagates into the tissue. A portion of the light is reflected back to the skin's surface where it is collected by the touch pad. This light transmits information on the skin's unique chemical properties, including the concentration of alcohol.

The shift from the Phase I prototype, which used a bulky spectrometer engine with moving parts, to a fully solid-state laser spectrometer (which better suited the automotive environment) has required extensive hardware and software research. The key enabling innovation is the ability to define an optimized subset of optical wavelengths which provide a high quality non-invasive alcohol measurement in humans (see Figure 4, Touch-based solid-state laser spectrometer approach). It was determined that the new approach required the use of modulated laser diodes to generate 40 unique wavelengths of light for optimal alcohol measurement. The necessary laser diode target specifications were derived from an analysis of the human subject system data with accurate comparative reference data.

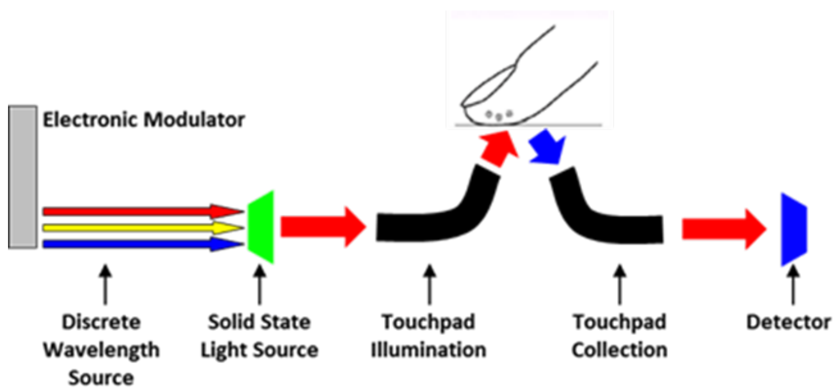


Figure 4. Touch-based solid-state laser spectrometer approach

The highest risk technical element of the touch-based system is the laser device fabrication which meets target specifications. Extensive, cutting-edge research has been undertaken to develop the requisite lasers and to assemble them in four multi-laser butterfly packages. Many of these laser wavelengths had not been manufactured before. The combined light source generated by the laser packages in a touchpad then has to illuminate the finger and is reflected back to the detector where alcohol measurements are made. After initial work to develop the laser diodes and packaging, a new supplier, Nanoplus, was selected with greater expertise in these areas. Each stage of the development process has required painstaking research which has been the subject of multiple patent applications. As with many new technology developments, complications have been experienced along the way. For example, research on the 4th generation (see

Figure 5, Evolution of touch-based DADSS sensor), revealed a problem with laser intensity fluctuations resulting in unreliable tissue alcohol measurements

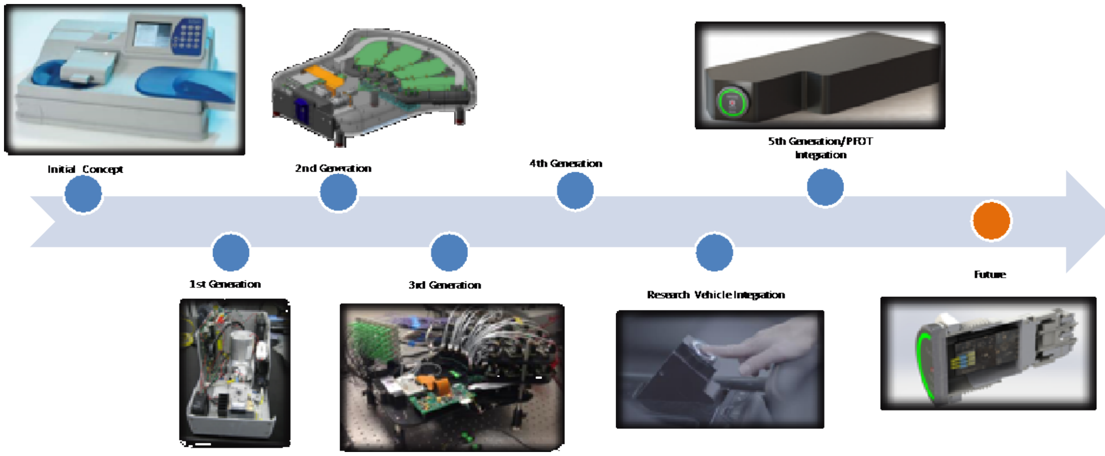


Figure 5. Evolution of touch-based DADSS sensor

FY 2017 has seen substantial advances in refining the Gen 4 sensor as well as the next generations, the more compact Gen. 5 and 6 sensors. Work has also proceeded on the methodology to limit sensor circumvention by the driver— an important issue for real-world functioning.

- An external review of the development team, technology validation, and technical approach was successfully completed.
- The source of the laser fluctuations was pinpointed as the result of the issues with the reference channel, and steps were taken to correct for that through redesign of the optical subsystems.
- A new optical touch pad systems design was completed.
- The updates demonstrated improved optical performance in laboratory testing.
- Designed and built new electronic subsystems for the Gen 4 sensor.
- Preliminary testing was undertaken of the new laser (STINGRAY) packages.
- Validated the base performance of the novel laser architecture enabling the use of Gen 5 sensors for future activities.
- The new laser package covering future Gen 6 sensors also was completed.
- Improvements were made to the surrogate tissue samples for greater reliability and precision.
- A new in-vitro sample chamber for laboratory testing of the sensors was designed, built, and tested.
- The first anti-circumvention prototype was built and tested.

Performance Specification Development

The Performance Specifications document is the primary tool for evaluating in-vehicle advanced alcohol detection technologies. The purpose of the document is to establish the DADSS Subsystem Performance Requirements for passenger motor vehicles. The document is based on input from the Technical Working Group. In addition to standards that specify the sensor's speed of measurement, accuracy, and precision, reliability requirements have been identified that conform to the automobile industry accepted 6σ (six sigma) level of reliability, thus minimizing the potential for system failure. International Organization for Standardization (ISO) principles also are followed to ensure that materials, products, and processes developed within the DADSS Program are acceptable for their purpose.

As research progresses, the DADSS Performance Specifications will require continued updating. In particular, the specifications will be revised to include new research findings and technology updates that are designed to address the following:

- Prevent manipulation (tamper resistance) and circumvention.
- Clear identification of the driver sample as well as differentiation of the driver sample from all passengers' samples and other interfering substances.
- Protection of data (cybersecurity).
- Ensuring integrity of communications between DADSS sensor and vehicle.

Standard Calibration Device (SCD) Research

As each new generation of the breath-and touch-based sensors are developed, researchers need to evaluate the sensors' performance. Sensor calibration is one of the primary processes used to confirm and maintain a sensor's accuracy and precision. The calibration process involves using reference or calibration standards, that is, samples of known value. The calibration standard in the U.S. is normally traceable to a national standard held by the National Institute of Standards and Technology (NIST). Using the NIST procedures allows calibration materials to be certified that they conform to the stated concentrations. Because the accuracy and precision requirements for DADSS alcohol sensors exceed those established for commercially available alcohol measurement devices by a large margin, it has not been possible to find existing NIST-certified sources of gas and liquid with the requisite accuracy and precision from which to produce the surrogate samples. Existing NIST reference materials have been used for accuracy and precision, but going forward, NIST reference materials for these levels of accuracy and precision may be developed by the DADSS team and if so, will be submitted to NIST for certification. The sample materials are referred to as Sample Reference Materials (SRMs), which when combined with the delivery methods, is considered to be the SCD.

A multi-pronged program of research and development was undertaken to address the various aspects of the calibration process. The initial efforts focused on the development of the breath and tissue surrogates that could meet the DADSS accuracy and precision requirements. This ongoing research is conducted in-house at the DADSS laboratory and in concert with outside providers of relevant materials. Once developed, the SCD's composition, accuracy, and precision has to be confirmed at these elevated specifications. The instrumentation necessary for such verification has to exceed the DADSS performance requirements by a significant order of magnitude. This necessitated a comprehensive search for suitable technological approaches and instrumentation that could exceed the already stringent DADSS requirements. Delivery systems were developed to deliver the breath and tissue samples to the instrumentation and the sensors. In addition, a series of experiments is in progress to develop calibration curves that pinpoint the accuracy and precision of the SCDs.

As research progressed, it became clear that two different measurement technologies would be required for sample and sensor calibration: that is, one for the breath-based SCD and another for the tissue-based SCD. A comprehensive evaluation of forensic toxicology instrumentation revealed emerging technologies with improved ability to quantify and identify ethanol in SCDs. Various approaches such as gas chromatography, liquid chromatography, and infrared spectroscopy were evaluated. The chosen instrumentation must quantify the chemical components within the samples with better precision and accuracy than the touch- and breath-based surrogates. The specified accuracy and precision of the DADSS sensors is 0.0003% at a BAC of 0.08%. This requires the surrogates to be measured with instrumentation that can meet a precision and accuracy target of 0.000075%.

The instruments not only quantify accuracy and precision but also identify substances in the tissue and breath samples. For the breath-based sample, the Fourier Transform Infrared Spectroscopy (FTIR) was selected over other technologies due to its ability to identify and precisely measure the intrinsic ethanol. For the tissue-based calibration, a High-Performance Liquid Chromatography (HPLC), with numerous detectors and interfacing with a FTIR, provides extremely precise measurements and identification of ethanol as well as the other compounds in the tissue surrogate. Today, compounds in trace concentrations as low as parts per trillion may easily be identified (see Figure 6, MKS Multi-gas 2030 FTIR for Breath–based samples and Waters Aquity HPLC for touch-based samples in the DADSS research laboratory).

Accuracy is limited by the calibration solution used. The advanced capabilities of the new instrumentation packages revealed deficiencies in the current calibration solutions. Contaminants were identified that previously went undetected. The accuracy of the breath-based SCDs from the same manufacturing lot were found to vary despite optimization of the systems to reduce errors beyond current industrial practices. Thus, to improve accuracy beyond the commercial off-the-shelf materials available, alternative ways to produce the calibration samples were researched and pursued. To improve tissue-based calibration solution accuracy, alcohol industry practices were studied, and systems were designed to precisely weigh and use other chemical properties to quantify the ethanol in a solution with extreme confidence. A similar approach to breath-based calibration samples is being developed.

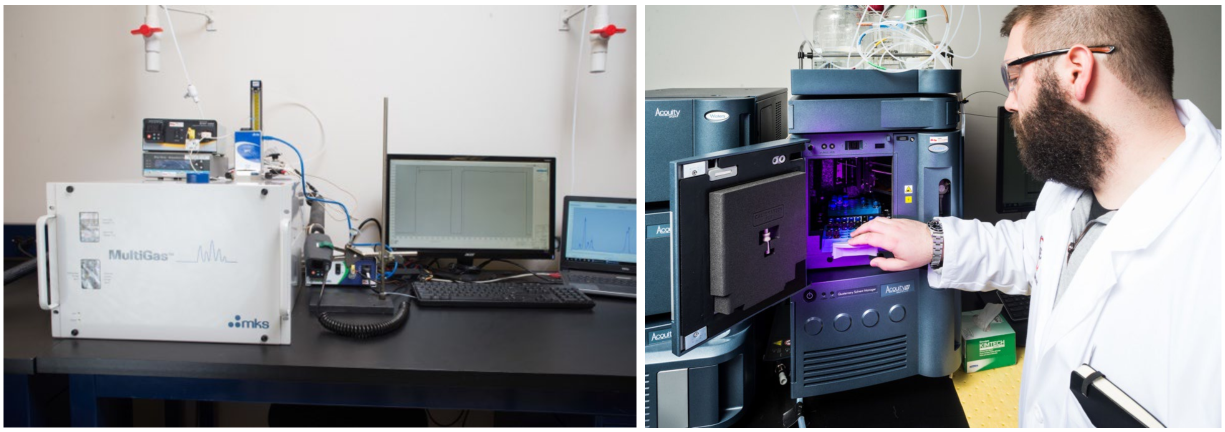


Figure 6. MKS Multigas 2030 FTIR for breath–based samples and Waters Aquity HPLC for touch-based samples in the DADSS research laboratory

Once the instrumentation had been identified that could meet the very exacting standards required, research was undertaken to not only develop highly accurate and precise calibration curves for the breath- and touch-based SCDs but also to characterize the performance of the Generation 3.1 breath-based sensor.

Extensive research has been conducted in FY 2017 that has resulted in substantial progress on a number of fronts, including development of calibration samples, measurement procedures, and delivery systems.

- Improvement of gases (SRMs). After demonstrating the dry gas can achieve DADSS's precision specifications (0.0003% BrAC), the DADSS laboratory focused on improving the dry and humidified gas precision to four times better than the precision requirement in the DADSS specification (new target is 0.000075 % BrAC). The humidified gas production (with numerous generation methods tested) and measurement system has been optimized for precision and measured to a precision of 0.000056 % BrAC using the MKS FTIR.
- Improvements were made to the gas delivery systems using pulsed dry and humidified gases to achieve a steady flow into the sensors for maximum performance. The purpose of this procedure is to improve control of the gas delivery

to the breath-based alcohol sensor and eventually allow for simultaneous testing of multiple breath-based alcohol sensors to improve testing efficiency.

- Testing of the Breath-Based Alcohol Sensor. Gen 3.0 sensors were tested to verify system performance under laboratory conditions as well as to validate the improved SRMs and SCDs. The Gen 3.0 sensor was plumbed inline after passing through the MKS FTIR to confirm the precision of the gas sample prior to measurement with the breath-based alcohol sensor.
- Improvement of tissue solutions (SRM). The Waters UPLC system with the Refractive Index (RI), Photodiode Array (PDA), and mass spectrometer (QDa) detectors has been optimized for measurement of the ethanol and other organic reagents in the tissue solutions using calibration curves generated by the DADSS laboratory. The ethanol calibration curve verified with NIST controls has demonstrated significant precision. To achieve this success numerous experiments testing different iterations of the experimental setups and measurement methods were conducted to determine the optimum chemistry and instrument configuration.
- The DADSS laboratory collaborated with SenseAir to ensure that they are now aligned with the DADSS laboratory in their use of the latest MKS Fourier Transform Infrared (FT-IR) spectroscopy instrument for calibration.

Human Subject Testing

Human subject testing, *in vivo* is a critical part of understanding how the DADSS sensors will perform in the real world when confronted with large individual variations in the absorption, distribution, and elimination of alcohol within the human body (blood, breath, tissue) over the myriad of factors that can affect BAC. Extensive research has provided a clear understanding of these factors with respect to venous (blood) alcohol and breath-alcohol when samples of deep lung air are used. However, the new measurement methods being researched under the DADSS program that determine alcohol levels from diluted breath samples and within human tissue are not well understood. In particular, the rate of distribution of alcohol, throughout the various compartments of the body under a variety of scenarios, has been the subject of ongoing study.

The fundamental challenge is to ensure that the levels of alcohol that are detected by the breath- and touch-based sensors do, in fact, reflect the concentration in venous blood, which is the gold standard of measurement. Based on an extensive review of the extant alcohol pharmacokinetics literature, intrinsic and extrinsic factors that can affect alcohol metabolism have been identified. Consequently, a comprehensive program of human subject research is underway, starting with the laboratory environment where better control of conditions can be exerted, followed by the in-vehicle environment where the sensors can be tested *in situ.*

The purpose of human subject testing is:

- To quantify the rate of distribution of alcohol throughout the various compartments of the body (blood, breath, tissue) under a variety of scenarios. Particular attention will be paid to the less well-known kinetics of tissue alcohol.
- To quantify alcohol absorption and elimination curves among a wide cross section of individuals of different ages, sex, body mass index (BMI), race/ethnicity, and using the different scenarios.

Significant progress has been achieved in conducting human subject testing at the DADSS Satellite Laboratory at McLean Hospital in Belmont, Massachusetts (See Figure 7, Human subject testing at DADSS satellite lab at McLean Hospital in Belmont, MA). Data collection is ongoing for five developed scenarios in an effort to quantify alcohol absorption and elimination. The scenarios explore a variety of conditions that are designed to mimic real-life situations. The five scenarios are as follows:

- Lag time. One of the most basic questions: in which compartment will alcohol first appear (blood, breath or tissue) after subjects consume a single large dose of alcohol? This information is critical to calibrating any temporal offsets and setting the timing of how the two prototypes will be implemented in the vehicle.
- Social drinking. The aim is to determine the profile of alcohol pharmacokinetics during a very common pattern of drinking, that is, steady drinking over an extended time and while eating only a small amount of snack-type food.
- Social drinking with a full meal. The aim is to quantify the time course of alcohol pharmacokinetics with the consumption of dinner along with alcohol. Participants will be served alcohol (on an empty stomach), followed by appetizers and then a full meal served with additional alcohol.
- Last call. This scenario is designed to simulate "Last Call," where participants drink several drinks at a programmed rate for a set period of time. When "Last Call" is made, the participant consumes additional drinks.
- Drinking during exercise. This scenario will simulate dancing and drinking in which individuals drink alcohol while engaging in episodes of physical activity. The effects of different intensities of exercise (light, moderate, and heavy) will be examined while participants drink alcohol over a period of 3-4 hours.

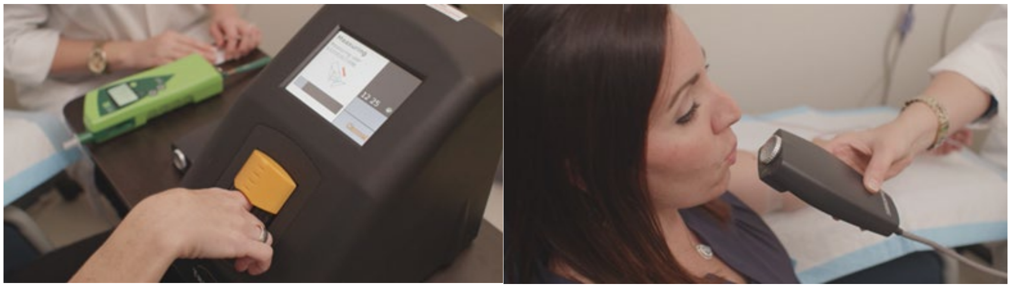


Figure 7. Human subject testing at DADSS satellite lab at McLean Hospital in Belmont MA

Significant progress has been made in FY 2017 in a number of areas, including method development and human subject testing. Many insights have been gained regarding the alcohol absorption and elimination curves and maximum BAC/BrACs reached by the subjects in a variety of different scenarios outlined on page 21.

- A human subject testing paradigm has been successfully implemented that allows the simultaneous collection of blood, tissue, and breath (using both an evidential device and the DADSS breath-based sensor) at two-minute intervals over a period of up to five hours. This methodology is important because it allows a direct comparison, in real time, of the BAC/BrAC in the various compartments.
- A unique protocol has been developed that allows the study of three participants at a time and maintains quality of measurement.
- In total, three versions of the breath sensor and two versions of the touch sensor have been evaluated.
- Substantial progress has been made in measuring the alcohol absorption and elimination curves across all of the scenarios outlined above, with a total of 78 subjects (4,500 blood samples).
- The results of testing to date indicate that each of the scenarios has an effect on the alcohol pharmacokinetic curves.
- Across the range of scenarios, a solid linear relationship between blood, breath- and tissue-based BAC/BrACs has been established. This indicates that the measurements produced by the various generations of breath-based and touch-based prototypes is consistent, reproducible, and correlates very well with the gold-standard method of measuring alcohol in the body—blood via gas chromatography.

Pilot Field Operational Testing (PFOT)

The specific aim of the PFOT effort is to conduct basic and applied research to understand the performance of the DADSS sensors, both physiologically and ergonomically, in the vehicle in a diverse set of geographic environments and with a large number of human subjects.

In support of the PFOT, General Motors donated 41 2017 Chevrolet Malibu's (valued at $1,332,500) to the DADSS Program. Of the 41 vehicles, 15 were delivered during the latter part of the 4th Quarter of 2017 that are currently being integrated with sensors and data acquisition.

Figure 8. 15 PFOT 2017 Chevrolet Malibu's

Furthermore, Generation 3.1 breath-based sensors will be integrated in a platform development vehicle using the Chevrolet Malibu. The purpose of the platform development vehicle is to complete a full system test including sensors, data acquisition system, telemetry system, reference sensor, and user interface prior to installation into the PFOT vehicles. These sensors will be passively sniffing or analyzing the vehicle cabin environment for the presence of alcohol. Data obtained from the first 15 vehicles will be analyzed and potentially incorporated into the algorithm of next generation sensors for improved passive sensing performance. Instrumentation packages have been developed, the data from which will be used to assess whether the DADSS sensors perform as intended in terms of repeatability, robustness, and readiness for field operational testing. Technical data gathered in these operational environments will also be used to refine the DADSS Performance Specifications and will be used for system design and product development.

Figure 9. Platform development 2017 Chevrolet Malibu integrated with the breath-based sensors.

Initial PFOT testing will be undertaken locally (in Marlborough, MA and Sterling, VA) to ensure that all sensors and data collection systems work as anticipated. Once all systems are verified, the full-scale PFOT will commence in various locations across the United States under widely varying climactic conditions, such low and high temperatures, low and high humidity, and at varying elevations. This will allow for a deeper analysis of the sensors performance in the operational context for which they were designed.

Significant progress has been made in FY 2017 in preparation for the PFOT, including:

- Development of the PFOT Test Plan for the observation and use of the DADSS sensors in a real-world driving environment. This includes the identification of regional sites which explore varying environmental conditions.
- Development of operational and system requirements for each regional site for day-to-day operations.
- Development of system and study requirements based upon the PFOT test plan and power analysis performed to derive the required number of test participants.
- Use cases that define the interactions between a role and a system to achieve the PFOT goals.
- Development of specifications as derived by the operational and system requirements.
- Successful completion of a preliminary design review for the Data Acquisition System (DAS).
- Successful development of the following design documents:
    - Roles and Responsibilities
    - Data Flow
    - DAS Hardware Analysis
    - DAS Software Analysis
    - Software Development Plan
    - Software Architecture and Design Document
    - DAS Hardware and Software Analysis Needs

Consumer Acceptance Research Program

A key component to ensure a successful launch of in-vehicle alcohol detection devices in the marketplace is consumer acceptance of the DADSS technology. This process encompasses several phases, beginning with awareness of the technology and how it works, to acceptance of the technology as a good auto safety system worth buying, developing a desire for the technology, and including demand for the technology in one's own car and those of family members.

In Phases II and III, qualitative and quantitative research was undertaken to explore public perceptions about and receptivity to new, optional in-vehicle alcohol-detection technologies. Baseline measurements of attitudes toward this new technology were established that can be tracked as efforts to increase awareness are accelerated. As well, messaging and language were researched to identify the most impactful approaches to capture and increase public acceptance of this new technology. Ongoing media monitoring and analyses assess the media landscape, that is, the tone and quality of the news articles to which consumers are exposed. Outreach also has been initiated to potential partners and stakeholders, who will help to engage the public and the media to increase awareness and acceptance. A key component of the public face of the technology has been the redesign of the DADSS website which provides multiple resources, including updated videos that put a human face on the technology and make the technology and its development accessible through straightforward explanations of the key concepts.

Activities in this area during FY 2017 consisted of:

- Updating of resources for the DADSS website included production of a new video that highlights the coalition of organizations behind DADSS. Also updated were the messaging guide for partners, technology one-pagers, and the research overview. Closed captioning was added to all videos for use at events with hearing-impaired audiences.
- Media support and ongoing media monitoring and analyses to assess the media landscape, that is, the tone and quality of the news articles to which consumers are exposed.
- Continued outreach to potential partners and stakeholders, who, once the DADSS technology is sufficiently developed for increased consumer and media scrutiny, will help to engage the public and the media to increase awareness and acceptance.

Patent Prosecution

As a result of the innovative research that is being undertaken under the DADSS Program, ground-breaking technologies and procedures are being developed that are the subject of patent applications. ACTS has continued to take a number of actions to ensure the commercial implementation of the DADSS technology. First, ACTS is prosecuting[11] patent applications in the major automobile-producing nations of the world to ensure production of any DADSS subsystem may proceed without threat of interruption. Specifically, applications are being prosecuted in China, the European Union, Canada, Hong Kong, Japan, South Africa, and the United States. Secondly, to further enhance the implementation of DADSS technology, the Board of Directors of ACTS has directed that the DADSS technology be made available on equal terms to anyone who, in good faith, wants to use the technology.

[11] Patent prosecution is the process of writing and filing a patent application and pursuing protection for the patent application with the patent office.

Finally, ACTS, in coordination with NHTSA, has structured ownership of the intellectual property generated through this research so that it vests with ACTS (a 501(c)(4) nonprofit) and not the individual members of ACTS or the DADSS technology providers. This helps to facilitate commercialization as rapidly as possible in at least two ways. Firstly, the pooling of resources by NHTSA and ACTS provides a reliable and cost-effective basis to promote the standardization of the technology, its widespread deployment, and acceptance by the general public. And secondly, ownership by ACTS avoids hindering commercialization through blocking patents which might result if there were multiple owners of the DADSS technology who could control the pace, scope, and price of commercialization. Table 1 summarizes the intellectual property generated through FY 2017 under the DADSS Program.

Table 1. Patent Applications to Date

TITLE	COUNTRY	STATUS	APPLICATION #
MOLECULAR DETECTION SYSTEM AND METHODS OF USE	United States of America	Closed[12]	13/838,361
SYSTEM FOR NONINVASIVE DETERMINATION OF ALCOHOL IN TISSUE	United States of America	Closed	61/528,658
SYSTEM FOR NONINVASIVE MEASUREMENT OF AN ANALYTE IN A VEHICLE DRIVER	United States of America	Closed	13/596,827
SYSTEM FOR NON-INVASIVE MEASUREMENT OF AN ANALYTE IN A VEHICLE DRIVER	United States of America	Pending	15/090,809
SYSTEM FOR NON-INVASIVE MEASUREMENT OF AN ANALYTE IN A VEHICLE DRIVER	China	Pending	201280042179.6
SYSTEM FOR NON-INVASIVE MEASUREMENT OF AN ANALYTE IN A VEHICLE DRIVER	Germany	Closed	NOT YET ASSIGNED
SYSTEM FOR NON-INVASIVE MEASUREMENT OF AN ANALYTE IN A VEHICLE DRIVER	European Patent Office	Pending	12827669.8

[12] The term closed means that the patent no longer is being pursued.

SYSTEM FOR NON-INVASIVE MEASUREMENT OF AN ANALYTE IN A VEHICLE DRIVER	Hong Kong	Pending	14109310.8
SYSTEM FOR NON-INVASIVE MEASUREMENT OF AN ANALYTE IN A VEHICLE DRIVER	Japan	Closed	2014-528520
SYSTEM FOR NON-INVASIVE MEASUREMENT OF AN ANALYTE IN A VEHICLE DRIVER	Japan	Pending	2016-176239
SYSTEM FOR NON-INVASIVE MEASUREMENT OF AN ANALYTE IN A VEHICLE DRIVER	South Africa	Pending	2014/02304
SYSTEM FOR NON-INVASIVE MEASUREMENT OF AN ANALYTE IN A VEHICLE DRIVER	PCT†	Closed	PCT/US12/52673
SINGLE/MULTIPLE CAPACITIVE SENSORS "PUSH TO START" WITH LED/HAPTIC NOTIFICATION AND MEASUREMENT WINDOW	United States of America	Closed	61/870,384
SYSTEMS AND METHODS FOR CONTROLLING VEHICLE IGNITION USING BIOMETRIC DATA	United States of America	Pending	14/315,631
SYSTEMS AND METHODS FOR CONTROLLING VEHICLE IGNITION USING BIOMETRIC DATA	Canada	Pending	2,920,796
SYSTEMS AND METHODS FOR CONTROLLING VEHICLE IGNITION USING BIOMETRIC DATA	China	Pending	201480047728.8
SYSTEMS AND METHODS FOR CONTROLLING VEHICLE IGNITION USING BIOMETRIC DATA	European Patent Office	Issued 3 038 865	EP14744677.7
SYSTEMS AND METHODS FOR CONTROLLING VEHICLE	Japan	Pending	2016-538915

IGNITION USING BIOMETRIC DATA			
SYSTEMS AND METHODS FOR CONTROLLING VEHICLE IGNITION USING BIOMETRIC DATA	South Africa	Pending	2016/00797
SYSTEMS AND METHODS FOR CONTROLLING VEHICLE IGNITION USING BIOMETRIC DATA	PCT	Closed	PCT/US14/44350
SEMICONDUCTOR LASER THERMAL CONTROL METHOD FOR COLLOCATED MULTIPLE WAVELENGTH TUNED LASERS	United States of America	Closed	61/889,320
SYSTEM AND METHOD FOR CONTROLLING COLLOCATED MULTIPLE WAVELENGTH TUNED LASERS	United States of America	Issued 9,281,658	14/456,738
SYSTEM AND METHOD FOR CONTROLLING COLLOCATED MULTIPLE WAVELENGTH TUNED LASERS	United States of America	Abandoned	15/058,650
SYSTEM AND METHOD FOR CONTROLLING COLLOCATED MULTIPLE WAVELENGTH TUNED LASERS	Canada	Pending	2,925,806
SYSTEM AND METHOD FOR CONTROLLING COLLOCATED MULTIPLE WAVELENGTH TUNED LASERS	China	Pending	201480055848.2
SYSTEM AND METHOD FOR CONTROLLING COLLOCATED MULTIPLE WAVELENGTH TUNED LASERS	European Patent Office	Pending	14755950.4
SYSTEM AND METHOD FOR CONTROLLING COLLOCATED MULTIPLE WAVELENGTH TUNED LASERS	Japan	Pending	2016-516589
SYSTEM AND METHOD FOR CONTROLLING COLLOCATED MULTIPLE WAVELENGTH TUNED LASERS	South Africa	Pending	2016/01639

SYSTEM AND METHOD FOR CONTROLLING COLLOCATED MULTIPLE WAVELENGTH TUNED LASERS	PCT	Closed	PCT/US14/50575
BREATH TEST SYSTEM	United States of America	Pending	14/421,371
BREATH TEST SYSTEM	Canada	Pending	2,881,817
BREATH TEST SYSTEM	China	Pending	201380054912.0
BREATH TEST SYSTEM	European Patent Office	Pending	13830956.2
BREATH TEST SYSTEM	Japan	Pending	2015-528442
BREATH TEST SYSTEM	South Africa	Pending	2015/01246
BREATH TEST SYSTEM	Sweden	Issued 536784	SE1250954-3
BREATH TEST SYSTEM	PCT	Closed	PCT/SE13/50991
HIGHLY ACCURATE BREATH TEST SYSTEM	United States of America	Pending	14/421,376
HIGHLY ACCURATE BREATH TEST SYSTEM	Canada	Pending	2,881,814
HIGHLY ACCURATE BREATH TEST SYSTEM	China	Pending	201380054007.5
HIGHLY ACCURATE BREATH TEST SYSTEM	European Patent Office	Pending	13831692.2
HIGHLY ACCURATE BREATH TEST SYSTEM	Japan	Pending	2015-528441
HIGHLY ACCURATE BREATH TEST SYSTEM	South Africa	Pending	2015/01247
HIGHLY ACCURATE BREATH TEST SYSTEM	Sweden	Issued 536782	SE1250953-5
HIGHLY ACCURATE BREATH TEST SYSTEM	PCT	Closed	PCT/SE13/50990
HEATER ON HEATSPREADER (HOH) LASER WAVELENGTH MODULATION CONTROL	United States of America	Closed	62/274,543
HEATER-ON-HEATSPREADER	United States of America	Pending	15/343,513
HEATER-ON-HEATSPREADER	PCT	Pending	PCT/US2016/060622
SENSOR SYSTEM FOR PASSIVE IN-VEHICLE BREATH ALCOHOL ESTIMATION	United States of America	Closed	62/312,476
SENSOR SYSTEM FOR PASSIVE IN-VEHICLE	United States of America	Pending	15/389,724

BREATH ALCOHOL ESTIMATION			
SENSOR SYSTEM FOR PASSIVE IN-VEHICLE BREATH ALCOHOL ESTIMATION	PCT	Pending	PCT/US16/68789
INTEGRATED BREATH ALCOHOL SENSOR SYSTEM	United States of America	Closed	62/171,566
INTEGRATED BREATH ALCOHOL SENSOR SYSTEM	United States of America	Pending	15/090,948
INTEGRATED BREATH ALCOHOL SENSOR SYSTEM	PCT	Pending	PCT/US2016/026024

†PCT means Patent Cooperation Treaty.

State Participation

In 2016, Virginia became the first state to partner with the DADSS Program through the Virginia Department of Motor Vehicles' Highway Safety Office. Virginia will be involved at various levels, from pilot manufacturing and vehicle integration, to field operational tests, to helping raise public awareness and gauging the public's acceptance of the technology. As the testing of the DADSS technology advances in the laboratory, Virginians will get an early look at the progress that has been made, provide input about the technology's convenience and operational features, and help refine and improve the technology before it becomes widely available.

Accounting of Federal Funds

Surface transportation reauthorization enacted in 2012, Moving Ahead for Progress in the 21st Century (MAP–21), amended section 403 of title 23 of the United States Code to authorize NHTSA to carry out a collaborative research effort on in–vehicle technology to prevent alcohol–impaired driving.[13] Funding for the DADSS Research Program for fiscal years 2013 through 2016 were made under the MAP-21 authorization. The surface transportation reauthorization enacted in December 2015, Fixing America's Surface Transportation (FAST) Act, amended section 403 of title 23 of the United States Code, continuing the authorization for DADSS research through fiscal year 2020.[14]

Funding for DADSS research was provided under the Highway Trust Fund (HTF) as part of the appropriations legislation enacted for fiscal year 2017. Federal funding

[13] 23 U.S.C. § 403(h) (as amended by Public Law 112–141, enacted July 6, 2012).
[14] 23 U.S.C. § 403(h) (as amended by Public Law 114–94, enacted December 4, 2015).

totaling $5,494,000 was authorized and ultimately appropriated for fiscal year 2017 (Table 2).[15]

Table 2. FY 2017 NHTSA Funding Available for In-Vehicle Technology Research to Prevent Alcohol-Impaired Driving

	Fiscal Year 2017
Funding for In–vehicle Technology Research	$5,494,000

The period of performance specified in the 2013 Cooperative Agreement initially covered a five–year period (September 30, 2013 to September 29, 2018). In December 2017, ACTS and NHTSA agreed to extend the award to September 29, 2020—the end of the program's express authorization in the FAST Act. Consistent with the extension, research has been planned for the entire agreement period. Table 3 provides a general statement regarding the use of Federal funding for fiscal year 2017 to carry out the DADSS research effort.

Table 3. Funding Status

Automotive Coalition for Traffic Safety
Advanced Alcohol Detection Technologies (DADSS)
DTNH22-13-00433
Funding Authorized, Appropriated and Expended

Funding Authorized & Appropriated – FY 2017		**$ 5,494,000**
FY 2017 Funding Expended		
Research & Development		$ 4,994,545
Indirect Rate		$ 499,455
	Total Expended	**$ 5,494,000**

[15] Consolidated Appropriations Act, 2017, Public Law No. 115–31, enacted May 5, 2017.