Sustainable Transportation Program

Providing innovative solutions that advance America's transportation systems.

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Clean air. Safe, congestion-free highways and transit systems. Efficient vehicles powered by domestic, renewable energy. More time to enjoy life.

Program Mission Drives Research

Through partnerships with government, industry, and academia, Oak Ridge National Laboratory's (ORNL) Sustainable Transportation Program research and development efforts are resulting in knowledge discovery and technology development, maturation, and implementation. The program drives four broad and integrated areas of concentration to advance the mobility of people and goods within America's transportation systems.

Vehicle

Research is under way to reduce cost and weight, and increase safety and reliability of next-generation hybrid, battery-powered, and fuel cell vehicles. Supporting these areas of research, experts are exploring innovative lightweighting and propulsion materials to address fuel efficiency, thermal management, emissions reduction, and manufacturing challenges associated with vehicle technologies. ORNL also conducts research on internal combustion engine technologies and control systems for improved efficiency and emissions control.

Energy

ORNL researchers are testing conventional and unconventional fossil-based fuels, non-petroleum fuels, and other alternatives to understand their effects on vehicle performance, fuel efficiency, distribution systems, and the environment. Through materials characterization, processing, and systems simulations, lab experts are developing next-generation batteries and manufacturing processes. ORNL is also addressing the bioenergy supply chain to enable large-scale sustainable production of biofuels.

Information

Information gathering, analysis, and sharing improves understanding and decision-making. Through data-based tools, such as fueleconomy.gov and the Transportation Energy Data Book, ORNL is helping consumers and officials make informed choices. ORNL modeling and visualization technologies are helping agencies prepare for and manage emergencies. Lab research is also enabling the development of intelligent technologies that connect vehicles, infrastructures, and users to improve safety, reduce congestion and travel time, and decrease fuel consumption and emissions.

Infrastructure

Safe, efficient passenger and freight movement and energy distribution rely on infrastructures. In addition to studying how alternative fuels affect current distribution systems, ORNL actively investigates more compatible infrastructure materials, such as those used in hydrogen pipelines. Researchers are also integrating data-collecting technologies into infrastructures, such as roads and weigh stations. From the infrastructures, real-time safety information is collected, such as brake performance, and traffic conditions can be monitored for managing day-to-day congestion or emergency situations.

National User Facilities

ORNL operates several designated Department of Energy (DOE) user facilities. The user facilities are designed to serve staff scientists and engineers, as well as researchers from universities, industry, foreign institutions, and other government laboratories. Those who want to access a user facility must submit a research proposal, the facility peer reviewers must accept the proposal, and a user agreement must be executed. Several user facilities house research laboratories where transportation-related R&D is conducted.

Center for Nanophase Materials Sciences (CNMS)

CNMS is a collaborative nanoscience user research facility for the synthesis, characterization, theory/modeling/simulation, and design of nanoscale materials. ORNL researchers at CNMS help develop advanced electrical-energy storage technologies with high energy and power densities, long life, low cost, little or no maintenance, and a high degree of safety.

Transmission electron microscopy for in situ characterization studies helps evaluate the stability of battery electrode materials during rapid charge-discharge cycling.

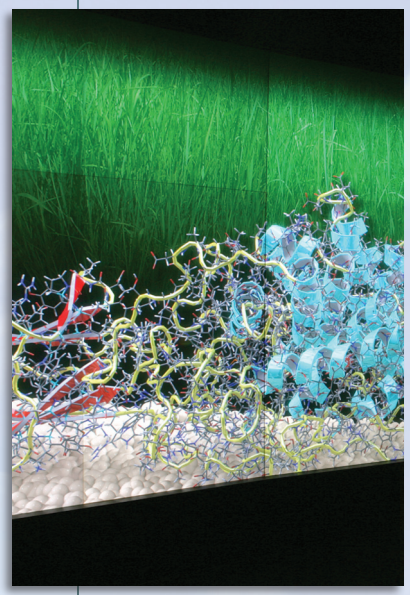
High Temperature Materials Laboratory (HTML)

HTML supports the development of advanced materials, providing researchers from U.S. industries, universities, and governmental agencies hands-on access to skilled staff and sophisticated instruments and facilities for materials characterization. HTML houses six user centers that contain specialized equipment designed for specific types of property measurements. Transportation-related research areas include catalysis, energy storage, lightweighting, high-strength weight reduction, vehicle propulsion materials, and thermoelectrics.

High Flux Isotope Reactor (HFIR)

HFIR is one of the world's most powerful research reactors. HTML manages a beamline at HFIR dedicated to the determination of residual stresses. Metalsa, which supplies side rails and chassis components to over 50% of the North American heavy truck market, used this beamline through the HTML User Program to validate a hole-cutting method for reducing side rail weight by 10%–20% in several of its current production models. This represents 100–200 pounds per truck or an annual savings of up to 30 million pounds of steel. Total fuel savings on 150,000 trucks driving 100,000 miles per year is estimated to be 3.8 million gallons each year.

Visualization on the NCCS EVEREST screen showing a cellulase enzyme in action on a cellulose surface with switchgrass in the background.



National Center for Computational Sciences (NCCS)

NCCS provides the most powerful computing resources in the world for open scientific research to understand how the physical world works and to use that knowledge to address pressing national and international concerns. Transportation-related work includes performing highly parallelized multi-length-scale computer simulations to help understand the physical causes of resistance of plant cell walls to hydrolysis—the major technological challenge to developing cellulosic bioethanol.

National Transportation Research Center (NTRC)

NTRC houses about half of ORNL's transportation R&D programs and laboratories. Its research centers focus on fuels, engines and emissions, power electronics and electric machines, heavy vehicle safety research, transportation analysis, and high risk/high value packaging.

Spallation Neutron Source Experimental Facility (SNS)

SNS is an accelerator-based neutron source at ORNL that provides the most intense pulsed neutron beams in the world for scientific research, including transportation applications. For example, its neutron-scattering research helps determine the atomic structure of high performance magnetic materials used in vehicles and can allow researchers to gather more detailed information on the microscopic properties and dynamics of optical fibers, leading to possible use in batteries and fuel cells for powering emission-free vehicles.

Weighing filters that have collected soot from engines enables emissions comparisons among various fuels, engine types, and aftertreatment devices such as diesel particulate filters.

Research Centers

Transportation R&D takes place in a number of highly sophisticated experimental research facilities. These research laboratories are designed to serve staff scientists and engineers, as well as researchers from universities, industry, foreign institutions, and other government laboratories.

Advanced Communications Laboratory

The Advanced Wireless Communications Laboratory's cross-cutting R&D complements related ORNL technologies, including sensors, electronics, controls, and systems engineering. Working with software-defined radio and cognitive radio platforms, the laboratory's researchers are helping improve the transportation sector by integrating multiple communications devices in a single platform.

Poplar trees, seedling pictured here, are a feedstock candidate for cellulosic ethanol.

BioEnergy Science Center (BESC)

The mission of BESC is to revolutionize how biomass is processed within five years. Leading experts at ORNL are working with others to develop biomass-based fuel solutions that are clean, viable, and affordable alternatives to petroleum-based fuels.

Center for Bioenergy Sustainability (CBES)

CBES is a leading resource for dealing with the environmental impacts and ultimate sustainability of biomass production for conversion to biofuels and biobased products. Its purpose is to use science and analysis to understand the sustainability of current and potential bioenergy production and distribution, to identify approaches to enhance bioenergy sustainability, and to serve as an independent source for the highest quality data and analysis.

Center for Transportation Analysis (CTA)

CTA develops integrated multimodal transportation solutions related to planning, policy, decision analysis, and technology deployment for freight and passenger transportation. The diverse CTA research portfolio encompasses transportation energy, economic, and environmental concerns; safety and security challenges; and mobility issues.

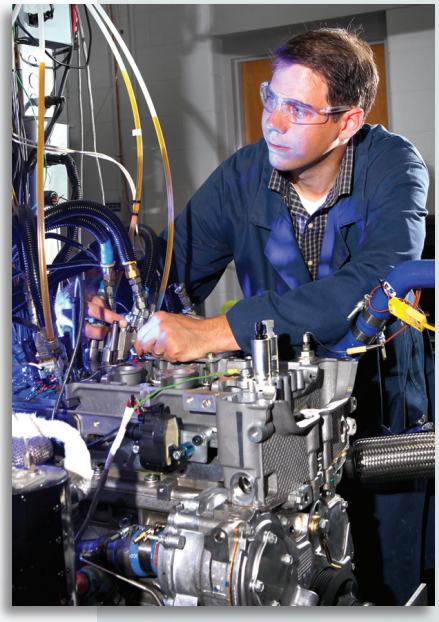
ORNL cognitive radio technologies are helping connect users, vehicles, and infrastructures.

Electronics Research Laboratory Clusters

Housed within the Measurement Science and Systems Engineering Division, these laboratory clusters provide a wide variety of electronic measurement, characterization, and development resources. A broad array of research activities are conducted in these facilities, including the development of custom integrated circuits, systems with embedded controllers, and communication systems. An extensive set of analytical equipment enables the characterization of complementary metal-oxide semiconductor devices as well as power electronics devices based on a number of technologies such as silicon, silicon carbide, and gallium nitride.

Fuels, Engines, and Emissions Research Center (FEERC)

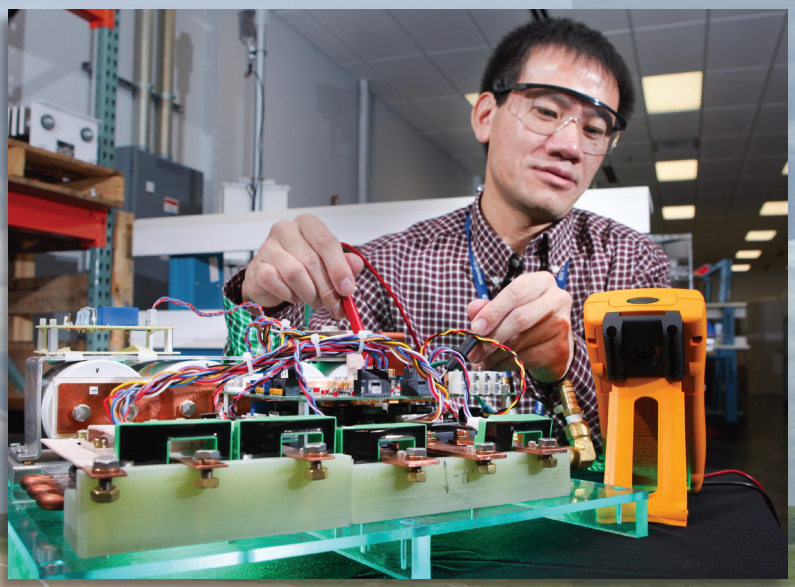
FEERC researchers help identify pathways to higher efficiency and emissions reduction by performing research at all levels, including engine system, components, basic chemistry, materials, and fuel effects. Fuels studied include natural gas and liquid fuels from conventional and unconventional fossil-based sources, and nonpetroleum fuels from synthetic and renewable sources.



Researchers use a variable valve-train engine to evaluate different types of fuels, including ethanol blends, and their effects on a combustion engine.

Power Electronics and Electrical Power Systems Research Center (PEEPSRC)

PEEPSRC develops and prototypes the next generation of power electronics and electric machines that will increase vehicle efficiency, reliability, and durability while reducing component cost, weight, and volume. Major areas of research include ongoing evaluations of hybrid vehicles and development of new power technologies that can operate without an internal permanent magnet.



Researcher tests a hybrid electric vehicle traction drive inverter system that can provide bidirectional plug-in battery charging capability.

Partnerships and Collaborations

ORNL participates in several transportation-related collaborations with government and industry to advance America's automotive industry.

FreedomCAR and Fuel Partnership is a collaborative effort among DOE, energy companies — BP America, Chevron Corporation, ConocoPhillips, Exxon Mobil Corporation, and Shell Hydrogen (U.S.)—and the U.S. Council for Automotive Research (USCAR) partners (Chrysler LLC, Ford Motor Company, and General Motors Corporation). The partners jointly conduct technology roadmapping, determine technical requirements, suggest R&D priorities, and monitor the R&D activities necessary to achieve the goals of the partnership. Technology roadmapping includes identification of existing barriers and challenges, technology-specific R&D goals (including cost targets), and milestones to progress toward the overall partnership goals. All the partners independently undertake their own research activities on advanced light-duty vehicle and/or fuel technologies relevant to achievement of the vision or partner independently through separate legal arrangements. USCAR partners jointly conduct related collaborative precompetitive R&D. Partner companies will make independent decisions on commercialization depending upon establishment of viable business cases.

Researchers examine a carbon-fiber composite preform. Such a lightweight material could improve a car's fuel economy.

21st Century Truck Partnership accelerates America's global competitiveness through the introduction of advanced truck and bus technologies that use less fuel, have greater fuel diversity, operate more safely and reliably, meet future emissions standards, and are cost effective. The program is pursuing dramatically improved fuel economy with near-zero emissions through advanced combustion engines, heavy hybrid drives, renewable fuels, and other vehicle improvements.

Intelligent Transportation

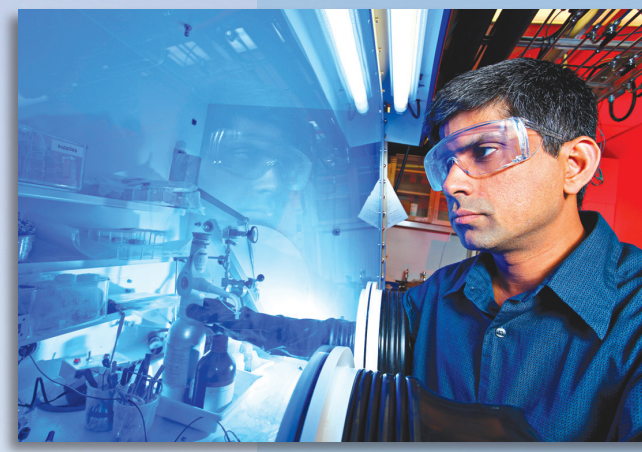
ORNL and partners are helping improve transportation safety, reduce congestion and travel time, and decrease fuel consumption and emissions by broadening the reach of intelligent transportation throughout America's civilian, commercial, and military sectors. Partners with federal and state agencies, industry, and academia include the U.S. Department of Transportation, U.S. Department of Defense, U.S. Department of Homeland Security, and the U.S. Department of Energy.

The Medium Truck Duty Cycle project evaluates vehicle systems, driving patterns, and related operating conditions.

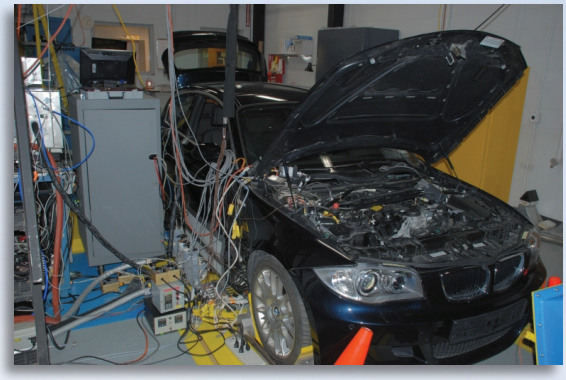
Program Spans Directorates, Applications

Transportation R&D brings together technology transfer specialists, commercialization experts, scientists, and engineers from multiple disciplines across ORNL, working together to advance laboratory-level science to technology maturation and implementation. The various research directorates involved include

- Biological and Environmental Sciences,
- Computing and Computational Sciences,
- Energy and Engineering Sciences,
- National Security,
- Neutron Sciences, and
- Physical Sciences.



Lithium-ion battery assembly for performance testing inside a glove box.



Comprehensive diagnostic and analytical tools are used in engine and emissions control research.

Sustainable Transportation R&D Activities

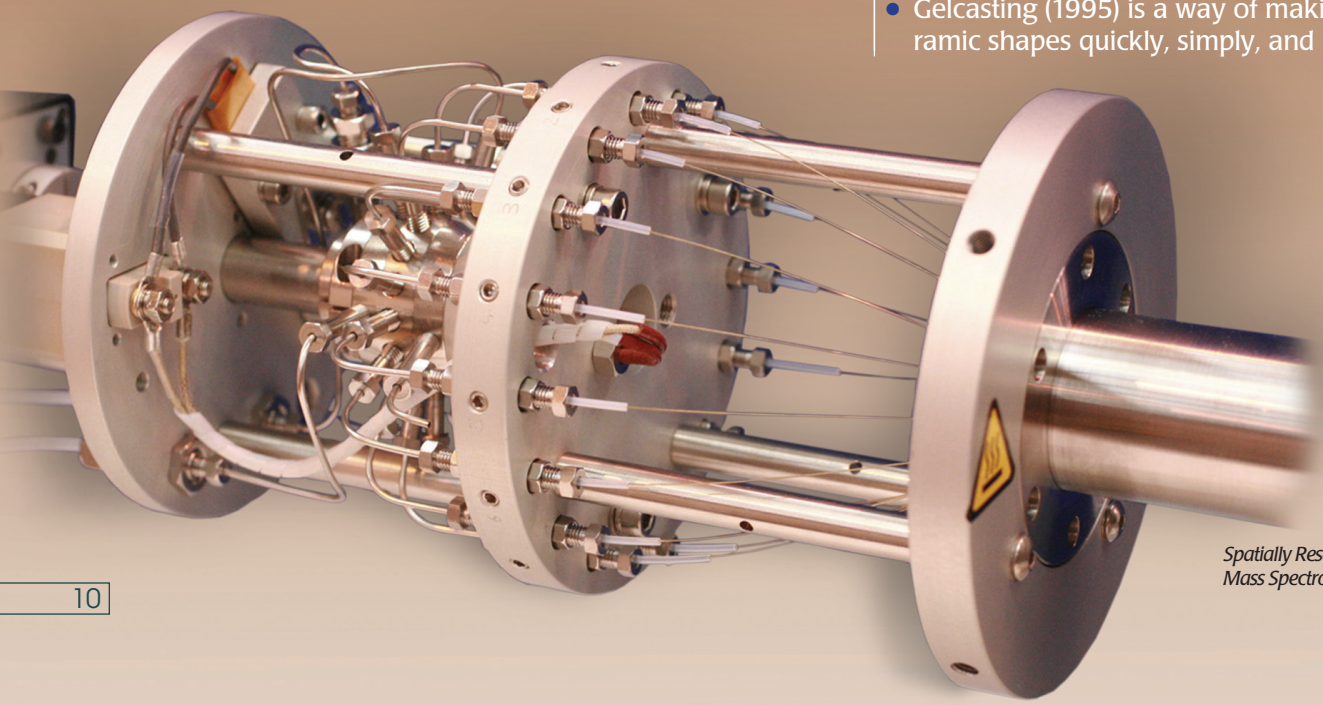
Advanced materials • Asset management • Batteries • Bioenergy • Combustion • Traffic congestion • Connectivity • Data Collection • Duty cycles • Economic analysis • Electrification • Emissions • Energy delivery • Energy impact • Energy security • Energy storage • Energy sustainability • Environmental impact • Freight modes • Freight patterns • Fuel cells • Fuel economy • Heavy vehicle safety • Hybrid vehicles • Hydrogen • Infrastructure investment • Intelligent transportation • Land protection • Logistics • Military transport • Operations analysis • Packaging • Passenger modes • Passenger patterns • Petroleum / nonpetroleum fuels • Policy and decision analysis • Population • Power electronics • Safety • Security • Sensor technology • Supply chain management • Supply chain and life-cycle analysis • Systems modeling and analysis • Tagging and tracking • Transportation system control and operations • Transportation system resiliency • Transit modes • Vehicle maintenance • Visualization

R&D 100 Awards

ORNL scientists and engineers, often in collaboration with an industrial partner, have won twelve R&D 100 Awards for developments that advance transportation systems.

- Sulfur-Carbon Nanocomposite Cathode Material and Additives for Lithium-Sulfur Batteries (2010) enables a more reliable, safer, and longer-lasting battery system to aid in the harnessing, storage, and use of electricity from renewable energy sources.
- Thermomagnetic Processing Technology (2009) enhances materials performance with an 85% higher stretch capability strength, enabling lighter weight designs.
- Spatially Resolved Capillary Inlet Mass Spectrometer (SpaciMS) (2008) provides detailed insights into chemical processes through fast-response, noninvasive gas composition measurements.
- Armstrong Process for Titanium Powder (2007) extracts titanium (a lightweighting candidate with other attractive properties) from ore much more cheaply than other methods, making titanium use more economically feasible in many applications.
- Metal Infusion Surface Treatment (MIST) (2006) is a process for infusing up to 51 elements into metal and alloy surfaces. MIST lengthens the life of metalworking and cutting tools, increases production rates, and reduces overall manufacturing costs.
- Robust Wireless Technologies for Extreme-Environment Communications (2004) were developed to provide real-time ship, container, and cargo tracking for maritime security.
- CF8C-Plus: New Cast Stainless Steel for High Temperature Performance (2003) drastically and cost-effectively improves high temperature durability, performance, and reliability.
- Spiral Notch Torsion Test (2002) is a portable testing and analysis system that yields precise data on the fracture toughness of many different kinds of materials.

- High Thermal Conductivity, Low-Density Graphite Foam (2000) offers thermal conductivity equivalent to that of aluminum at one-fifth the weight.
- Metal-Compression Forming (1997) consistently produces parts with fewer defects and properties comparable to forged pieces and can create complex geometries at high throughput rates and relatively low cost.
- Thin-film Rechargeable Lithium Battery (1996) is less than 15 micrometers thick. It has high energy and power densities, can be cycled thousands of times, and can be fabricated in any shape and size.
- Gelcasting (1995) is a way of making complex ceramic shapes quickly, simply, and economically.



Spatially Resolved Capillary Inlet Mass Spectrometer (SpaciMS).

Moving in the Right Direction

Providing innovative solutions that advance America's transportation systems. So just how does the Sustainable Transportation Program positively impact our country's future?

Quality of Life

Drivers can spend less time in traffic and more time with family and friends. They will have more choices and the freedom and means to choose between filling up or plugging in. Journeys will be safer, the environment cleaner.

Economic Prosperity

Energy sources will be domestic, with energy efficient production processes creating new jobs and a "greener" economy. Innovative partnerships will revitalize the automotive industry. Consumers will spend less on fuel due to vehicle improvements, advancements in energy sources, and less highway congestion. Business will be more productive with more effective and efficient freight movement.

National Security

America will no longer fear fuel shortages or rely on foreign countries for oil. Plans will be in place to ensure safe passenger evacuations and freight movement in times of emergency. Borders, ports, rail systems, and roadways will be safe, and military transportation will be more efficient and secure.

Transportation research activities are directed and funded primarily by the DOE Office of Energy Efficiency and Renewable Energy, specifically the Vehicle Technologies, Biomass, and Fuel Cell Technologies Programs. The Department of Transportation, Department of Defense, Department of Homeland Security, Environmental Protection Agency, industry, and other partners support ORNL's research to advance America's transportation systems.

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