MIT ILP
INDUSTRIAL LIAISON PROGRAM

MIT Industry Brief

MIT and Automotive Industries

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MIT and Automotive Industries

The Massachusetts Institute of Technology (MIT) is a leading center of research and education on topics important to the automotive industry and its suppliers such as:

- *Automotive materials*
- *Electrical and control systems*
- *Engines, fuels, energy*
- *Environmental impact, sustainability, policy*
- *Motor vehicle design, manufacturing*
- *Robotics, autonomous systems*
- *Transportation systems and supply chain management*
- *Urban mobility*

Below are brief descriptions of a selection of MIT centers, departments, groups, and labs conducting research and education in these areas. Please note that this is not a comprehensive summary of research being conducted at MIT in the topic areas listed above and the center or lab, etc., may fall into more than one category.

AUTOMOTIVE MATERIALS

The ***Center for Materials Science and Engineering (CMSE)*** fosters research and education in the science and engineering of materials. Example research areas: Harnessing in-fiber fluid instabilities for scalable and universal multidimensional nanosphere design, manufacturing, and applications; nanoionics at the interface: charge, phonon, and spin transport; chemically modified carbon cathodes of high capacity Li-O2 batteries.

The ***Impact and Crashworthiness Laboratory*** research interests are in the area of dynamic plasticity, structural failure, crashworthiness, ultralight material, and more recently ductile fracture.

The ***Materials Processing Center (MPC)*** research covers the full range of advanced materials, processes, and technologies including: electronic materials; batteries and fuel cells; polymers; advanced ceramics; materials joining; composites of all types; photonics; electrochemical processing; traditional metallurgy; environmental degradation; materials modeling; materials systems analysis; nanostructured materials; magnetic materials and processes; biomaterials; and materials economics.

The ***Materials Systems Laboratory (MSL)*** studies the competitive position of materials in specific applications (assessment of candidate materials and process technologies; evaluation of the economic and non-economic consequences of each alternative) toward developing tools useful at an early stage of product design. Methodologies include technical cost modeling, lifecycle cost and emissions tracking, decision analysis techniques, systems dynamics modeling, and system cost modeling.

Research in the ***Department of Materials Science and Engineering (DMSE)*** ranges from the purely scientific to applied studies, and involves perspectives of chemistry, physics, electronics, the artistic and historical aspects of materials, design, and entrepreneurial ventures. Interests span the entire materials cycle from mining and refining of raw materials, to production and utilization of finished materials, to disposal and recycling.

ELECTRICAL AND CONTROL SYSTEMS

The goal of the ***Active Adaptive Control Laboratory*** is to investigate complex intelligent systems that require adaptation, learning, and control. Projects include energy distribution in smart grid, co-design of control and implementation platform for cyber-physical systems, adaptive flight control systems, and adaptive technology for automotive platforms.

The ***Auto-ID Labs at MIT*** traces its roots back to the 1999 founding of the Auto-ID Center, which laid much of the groundwork for the standardization of RFID technology and the introduction of the Electronic Product Code™ (EPC). Now a member of the global Auto-ID Labs network, the Lab continues research on the evolution and application of RFID systems, as well as other disruptive Internet of Things technologies.

The ***Laboratory for Electromagnetic and Electronic Systems (LEES)*** research areas include electronic circuits, components and systems, power electronics and control, micro and macro electromechanics, electromagnetics, continuum mechanics, high voltage engineering and dielectric physics, manufacturing and process control, and energy economics. The laboratory's extensive automotive electrical system research program brings together experts in digital and analog circuit design, simulation, electromechanics, micro-fabrication, power electronics, electrochemistry and economics.

The RLE ***Power Electronics Research Group*** systematically investigates physical and engineering issues relevant to the transformation of energy and energy production. Specifically, the group is working on making power conversion more energy efficient. In addition to developing fundamental power conversion technologies, we are applying them in a variety of applications. Automotive power generation and control is one such area.

ENGINES, FUELS, ENERGY

The ***Sloan Automotive Laboratory*** conducts extensive research in the areas of internal combustion engines and fuels, fundamental fluid/thermal/combustion studies, and assessment of advanced propulsion and vehicle technologies, and especially their energy consumption and environmental impacts. The laboratory has ten test cells equipped with modern facilities for combustion, engine performance, and emissions research, and is equipped with the appropriate instrumentation, diagnostics, and computer systems.

The ***Engine and Fuels Research Consortium*** projects are focused on spark-ignition engine combustion, emissions formation processes, and mixture preparation issues. Ongoing research: Gasoline direct-injection engine processes; effect of air and cooled EGR dilution on engine knock; role of crevice effects in downsized, turbocharged engines; potential of alcohol fuels in downsized turbocharged engines to increase compression ratio, increase downsizing plus boosting or both.

The ***Lubrication in Internal Combustion Engines Consortium*** develops knowledge and analytical tools for the engine lubrications systems to help the product development of our industry members. The group's approach is to combine the efforts from experiments, modeling, and close interaction with industry members. The group's focus is to complete models at all levels for power cylinder optimization and minimization of engine friction.

The ***Oil and Engine-Lubricant-Aftertreatment Research Consortium*** works to optimize the engine, lubricants, and additives for robust emission aftertreatment systems. This Consortium brings together synergistically participants from the lubricant, additive, engine, catalyst, emission-control industries and the government to address the complex interactions in the combined engine-oil-aftertreatment system.

The ***Center for 21st Century Energy*** research focuses on technologies for efficient and clean energy conversion and utilization, and encompasses existing and emerging technologies at the systems, engineering and scientific levels, including engines and combustion, thermoelectricity, fuel cells and batteries, solar energy and wind power systems, energy efficient buildings, carbon capture, hydrogen and alternative fuels, and water purification and desalination.

The ***Electrochemical Energy Lab @ MIT (e2Lab)*** probes the underlying molecular-level mechanisms of catalytic and charge transfer reactions, and ion/electron transport and examines the impact of these mechanisms on performance in electrochemical energy devices, including in lithium-ion batteries, lithium-air batteries, PEM fuel cells and solid oxide fuel cells. Research is centered on understanding the electronic structures of surfaces/interfaces, searching for descriptors of surface reactivity, catalytic activity and charge transfer processes, and applying fundamental understanding to design surfaces for electrocatalysis and for electrochemical energy storage.

The ***Reacting Gas Dynamics Laboratory (RGD Lab)*** is focused on high efficiency, low-carbon energy from hydrocarbon sources, as well as hybridizing with concentrated solar thermal energy, through thermochemical conversion and combustion. The lab develops, validates, and applies multiphysics multiscale simulation techniques to engineer optimal, clean, low CO2-energy systems based on sound fundamental understanding of the underlying mechanisms. Innovations include clean combustion for propulsion and power, gasification for power

and biofuel production, and oxy-combustion and electrothermochemical conversion in ion-transport membrane reactors and high-temperature fuel cells for CO2 capture.

Mechanical Engineering Department Research in Energy Science and Engineering focuses on technologies for efficient energy conversion and utilization, which aim to meet the urgent challenge of a safe, sustainable energy supply. Research spans the following technical areas: automotive power plants and ocean propulsion systems; fossil fuel combustion; wind power; solar energy; electrochemical energy storage; thermoelectric technologies; fuel cells; hydrogen production and storage; refrigeration; thermohydraulics of power systems; energy efficiency in a wide range of systems; ocean energy; certain aspects of nuclear energy; hybrid engines; thermal management of electronics; and energy efficient buildings.

ENVIRONMENTAL IMPACT, SUSTAINABILITY, POLICY

The ***Carbon Capture & Sequestration Technologies Program*** conducts research into technologies to capture, utilize, and store CO2 from large stationary sources. The program's research examines carbon sequestration from multiple perspectives—technical, economic, and political. Research interests include technology assessments, economic modeling, analysis of regulatory and political aspects, and development of a Carbon Management Geographic Information System (GIS).

The ***Carbon Sequestration Initiative (CSI)*** is an industrial consortium aims to provide an objective source of assessment and information about carbon sequestration; to establish an information network to provide timely updates on relevant activities and new findings; to explore the societal and technical aspects of carbon sequestration; to educate a wider audience on the possibilities of carbon sequestration; to link industry to expanding government activities on these topics; to stimulate and seed new research ideas; and to create an annual forum for strategic thinking and identification of new business opportunities.

The MIT ***Center for Energy and Environmental Policy Research (CEEPR)*** is dedicated to rigorous and objective empirical research on issues related to energy and environmental policy to support decision-making by government and industry. The relevance and validity of the research is enhanced through cooperation with government and industry associates in countries around the globe. The center's research is focused broadly on: electricity restructuring; emissions trading; climate change; human welfare and the environment; investment, finance, and risk management.

The ***MIT Energy Initiative (MITEI)*** is working on key elements of the complex energy challenge through multidisciplinary research activities shaped so as to address the linked supply and demand, security, and environmental challenges. MITEI's research program focuses broadly on: 1) Innovative technologies and underlying policy analysis; 2) transformational technologies to develop alternative energy sources that can supplement and displace fossil fuels; 3) global systems to meet energy and environmental challenges; and 4) tools to enable innovation, transformation, and simulation of global energy systems.

The ***Civil & Environmental Engineering Department's Transportation*** group has provided leadership in the field of transportation research for many years by emphasizing an interdisciplinary systems approach incorporating engineering, urban planning, transport system management and public policy. The group is now applying this interdisciplinary approach to the concept of sustainable transportation to address the critical issues confronting the world today.

MOTOR VEHICLE DESIGN, MANUFACTURING

The ***Computer Science and Artificial Intelligence Laboratory (CSAIL)*** researchers have been key movers in developments like time-sharing, massively parallel computers, public key encryption, the mass commercialization of robots, and much of the technology underlying the ARPANet, Internet and the World Wide Web. CSAIL's approximately 50 research groups are organized into three focus areas: artificial intelligence, systems, and theory. Research is conducted in almost all aspects of computer science, as well as exploring revolutionary new computational methods for advancing healthcare, manufacturing, energy and human productivity.

The MIT ***Consortium for Engineering Program Excellence (CEPE)*** is a research group that brings the wisdom of lean thinking to the management of large-scale engineering programs by integrating program management, systems engineering, product development and systems engineering approaches to build engineering programs that consistently delight their stakeholders. The research program is supported by its sponsors and a group of industry and government subject matter experts.

The ***Environmentally Benign Manufacturing (EBM)*** group is focused on examining the environmental impacts of the product lifecycle, and focused on the design, manufacturing, and end-of-life stages. Research areas: the thermodynamic, economic, and life cycle assessment of manufacturing processes and systems, products and recycling systems, and the environmental effects from the consumption side of the issue.

The ***Industrial Performance Center (IPC)*** studies innovation, productivity and competitiveness in the U.S. and around the world. The Center specializes in bringing together multidisciplinary teams of researchers in engineering, science, management and the social sciences to carry out innovative, applied research on industrial growth and transformation, national and regional economic growth and competitiveness, and innovation performance. The IPC research program is organized around the following broad themes: energy; globalization; innovation; and production.

The ***Interactive Robotics Group*** is developing innovative methods for enabling fluid human-robot collaboration. The group's vision is to harness relative strengths of humans and robots to accomplish what neither can do alone. The focus is on developing robots that work in teams with people in high-intensity and safety-critical applications, including industrial manufacturing, disaster response, and space exploration.

The ***Laboratory for Manufacturing and Productivity (LMP)*** is an interdepartmental laboratory dedicated to the development and application of the fundamental principles of manufacturing systems, processes, and machines. Research and education is focused in the areas of design, analysis, and control of manufacturing processes and systems.

The ***Leaders for Global Operations (LGO)*** program is a collaboration among MIT Sloan School of Management, MIT School of Engineering, and more than 20 industry partners. LGO students receive two degrees in two years (an MBA or an MS in Management from MIT Sloan School of Management, and an MS degree from the School of Engineering). The program provides a solid background in manufacturing processes, design and development, operations management, information technology, teamwork, leadership, change management, and systems thinking. LGO partner companies play a vital role in the program in several ways, one of which is by providing students with a six-month, on-site internship.

The ***MIT Solar Electric Vehicle Team (SEVT)*** is a recognized student group at MIT that draws on a broad range of technical knowledge encompassing all fields of engineering and science. Team membership provides an intense educational experience which teaches practical skills impossible to communicate in the classroom environment, turning students into engineers. In addition to providing real-world design and manufacturing experience, involvement in the team develops project management and business skills.

ROBOTICS, AUTONOMOUS SYSTEMS

The ***Aerospace Controls Laboratory (ACL)*** researches topics related to autonomous systems and control design for aircraft, spacecraft, and ground vehicles. Theoretical research is pursued in areas such as: decision making under uncertainty; path planning, activity and task assignment; estimation and navigation; sensor network design; robust control, adaptive control, and model predictive control.

The ***Aerospace Robotics and Embedded Systems (ARES) Group's*** mission is the development of theoretical foundations and practical algorithms for real-time control of large-scale systems of vehicles and mobile robots. Application examples range from UAVs and autonomous cars, to air traffic control, and urban mobility. The group researches advanced algorithmic approaches to control high-dimensional, fast, and uncertain dynamical systems subject to stringent safety requirements in a rapidly changing environment.

The ***Laboratory for Information and Decision Systems (LIDS)*** is committed to advancing research and education in systems and control; communications and networks; and inference and statistical data processing. LIDS research spans the full range from fundamental research and the development of new methodologies, to applications of major significance. Sample areas include: Coordination of unmanned autonomous systems; energy information systems; intelligence, surveillance, and reconnaissance (ISR) systems; network scheduling and routing; sensor networks; ultra-wideband and other emerging communications technologies.

The overarching goal of the ***Model-based Embedded and Robotic Systems Group (MERS)*** is to develop "cognitive robots," robots that are able to think and act much like humans do. The group is focused on allowing robots to be programmed by humans by being given high-level goals instead of low-level scripts, to team with a human to accomplish some task, and to reason about themselves and the environment to detect unanticipated changes or hazardous situations. Sample research areas include human-robot teamwork in manufacturing, personal transportation system, autonomous under water vehicles, and deep space exploration.

The ***Robotic Mobility Group*** focuses on the modeling, design, control, motion planning, and sensing for robotic systems operating in unstructured environments. Project examples include: Human-inspired autonomous vehicle highway navigation; terramechanics for small, lightweight robots; classification and modeling of forested terrain from unmanned ground vehicles.

The research goals of the ***Robust Robotics Group*** are to build unmanned vehicles that can fly without GPS through unmapped indoor environments, robots that can drive through unmapped cities, and to build social robots that can quickly learn what people want without being annoying or intrusive.

The group focuses on problems of planning and control in domains with uncertain models, using optimization, statistical estimation and machine learning to learn good plans and policies from experience.

TRANSPORTATION SYSTEMS & SUPPLY CHAIN MANAGEMENT

The ***Center for Transportation & Logistics (CTL)*** is widely recognized as an international leader in supply chain management education and research. Along with basic contributions to the understanding of transportation system planning, operations and management, its efforts include significant contributions to logistics modeling and supply chain management for shippers; to technology and policy analysis for government; and to management, planning and operations for trucking, railroad, air and ocean carriers.

The ***Database Group at MIT (DBg)*** conducts research on all areas of database systems and information management. In CarTel, the group is building a system for managing data in the face of intermittent and variable connectivity. The focus, in particular, is on automotive applications that involve high-rate sensing of road, traffic, and infrastructure conditions. The two key technologies being developed are CafNet, a carry-and-forward network stack, and a distributed, signal-oriented, priority-dgriven query processor.

The ***MIT Forum for Supply Chain Innovation (the Forum)*** is a unique community composed of academics and industry members whose support allows Forum researchers to provide customer-focused solutions to design and manage the new supply chain. The rigorous approach used by MIT Forum guides businesses through the latest innovations in supply chain management, technology and implementation techniques. Members of the supply chain community have the flexibility and opportunity to participate in both industry–wide research into the supply chain as well as initiating their own specific research project.

The ***Intelligent Transportation Systems (ITS) Lab*** has conducted numerous studies of transportation systems and developed network modeling and simulation tools. The lab's areas of research include discrete choice and demand modeling techniques, activity-based models, freight transport modeling, and data collection methods for behavioral modeling. The ITS Lab is spearheading several projects on the planning, design, and operation of future passenger and freight systems.

The ***Operations Research Center (ORC)*** education and research draws upon ideas from engineering, management, mathematics, and psychology to apply scientific methods to decision-making. ORC faculty contribute to a wide range of application domains such as flexible manufacturing systems; financial engineering services; air traffic control; transportation systems; public services, such as urban emergency systems; safety and risk analysis in air transportation; and more.

The ***Systems Engineering Advancement Research Initiative (SEAri)*** performs collaborative research to address advanced systems engineering challenges. The research group has a strong foundation in the space system and defense design and architecture domain, with more recent work branching into the transportation and infrastructure systems domain. While these domains represent past work and ongoing areas for case study analysis, the methods and practices developed by SEAri aim for truly cross-domain applicability.

URBAN MOBILITY

The ***MIT Age Lab*** research program works with business, government, and NGOs to improve the quality of life of older people and those who care for them. AgeLab's research addresses transportation safety, impact of health, wellness and medication use on operator performance, personal transportation choices, future travel demand, the promise and trade-offs of new technologies in the automobile, vehicle services and design, and mobility alternatives in the context of livable communities.

The MIT ***Center for Digital Business*** is world's largest center for research focused on the digital economy. The Center has established a large-scale research program to investigate the latest trends and techniques in digital business. The core of this program is the custom matching of sponsor companies with MIT faculty to form research teams that address issues that are relevant to both industry and academia. Three broad areas of focus are digital marketing, digital productivity, and digital services and the Cloud.

The goal of ***Future Urban Mobility*** is to develop, in and beyond Singapore, a new paradigm for the planning, design and operation of future urban mobility systems. At the heart of the research effort is SimMobility, a simulation platform with an integrated model of human and commercial activities, land use, transportation, environmental impacts, and energy use.

MIT Media Lab researchers work in more than 25 research groups on more than 350 projects that range from digital approaches for treating neurological disorders, to a stackable, electric car for sustainable cities, to advanced imaging technologies that can "see around a corner."

The ***City Science Initiative*** is a unique network of research groups experienced in the design of technology and infrastructure, the analysis of big data, and the development of rigorous

scientific theories. The City Science Initiative provides an interdisciplinary nexus where these research networks join to improve the design, livability and understanding of high performance urban environments focused on intelligent, sustainable buildings, mobility systems, and cities.

The ***Changing Places*** group proposes that fundamentally new strategies must be found for creating the places where people live/work, and the mobility systems that connect them, in order to meet the profound challenges of the future. The group is investigating how new models for urban architecture and personal vehicles can be more responsive to the unique needs and values of individuals though the application of disentangled systems and smart customization. The group is also developing technology to understand and respond to human activity, environmental conditions, and market dynamics.

The ***MIT Mobile Experience Lab*** uses personal mobile devices to unlock potential in the physical world around us. The group seeks to radically reinvent and creatively design connections between people, information, and places. The group conducts both academic and field research, designs elegant and simple solutions to problems, and tests its ideas through physical and digital prototypes to ensure. Broad research areas include transportation and urban spaces, digital platforms, among others.

The mission of the Massachusetts Institute of Technology is to advance knowledge and educate students and others in science, technology, and additional areas of scholarship. MIT is committed to generating, disseminating and preserving knowledge and to working to bring this knowledge to bear on the world's great challenges. As part of its mission, MIT maintains relationships with industrial organizations that enable the exchange of ideas in the context of real-world problems and demonstrate how principles studied at MIT are applied to generate practical benefits for industry and society. MIT's Industrial Liaison Program helps develop these relationships by facilitating industry's access to MIT and its vast resources.