

# DRAPER LABORATORY

## 2008 TECHNOLOGIES AND APPLICATIONS

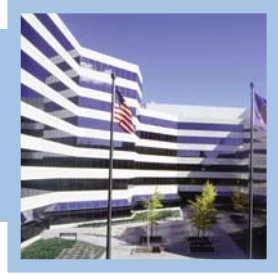
Copyright © 2009 by The Charles Stark Draper Laboratory, Inc.  
All rights reserved.

Photo credit:  
pg. 6 U.S. Navy; pg. 12 NASA

# Contents

Draper Laboratory Overview	4
Strategic Systems	6
Tactical Systems	9
Space Systems	12
Special Operations	14
Biomedical Engineering	17
Energy Solutions	20
Geospatial Solutions	22
Independent Research & Development	24
Working at Draper Laboratory	27
Draper Educational Programs	29

## Draper Laboratory Overview



### **The Charles Stark Draper Laboratory, Inc.**

The Charles Stark Draper Laboratory, Inc. is an independent, not-for-profit research and development organization serving the national interest in applied research, engineering development, technology transfer, and advanced technical education. Sponsors include the U.S. Navy, U.S. Air Force, U.S. Army, Defense Advanced Research Projects Agency (DARPA), NASA, and other government agencies. More than 90% of the Lab's work is government-funded, but Draper also performs work for the commercial sector and has a robust Independent Research & Development (IR&D) program.

Draper employs more than 900 engineers, scientists, and technicians who work on a wide variety of projects in core business areas—strategic systems, space systems, tactical systems, special operations, geospatial systems, biomedical engineering, and energy.

Competencies leveraged in Draper's work are guidance, navigation and control: inertial, strategic and tactical systems; miniature low-power systems; information and decision systems; complex, reliable systems; and biomedical engineering.

## **Some of the Laboratory's current initiatives include:**

- Modernizing the nation's strategic missile guidance systems.
- Advancing military operations with precision guidance and control and mission planning technologies.
- Developing technology for advanced space systems for human space exploration, space science, and military space capabilities.
- Creating vanishingly small systems for close-in intelligence, surveillance, and reconnaissance.
- Exploiting the synergy between engineering and life sciences for applications such as point-of-care diagnostics, implantable therapeutics and diagnostics, medical informatics, and regenerative medicine.
- Applying sensors and controls for improved efficiency, safety, and security of the nation's energy systems and infrastructure.
- Providing information management and development of enterprise systems in the storage, retrieval, and analysis of geospatial information.

Draper's mission to serve the national interest is accomplished not only through application of its technologies to sponsored programs, but also by transferring technology to industry, providing advanced technical education programs, and investing in internal research and development to address long- and short-term sponsor needs. A Technology Licensing Office helps commercialize Draper-developed technologies.

Draper is named for Dr. Charles Stark Draper, widely recognized as the "father of inertial navigation" and credited with pioneering and developing the theory, enabling technology, and early applications of inertial measurement systems. He achieved his successes at MIT, where he formed a teaching laboratory within the Department of Aeronautics and Astronautics, the MIT Instrumentation Laboratory, which later became the independent, not-for-profit R&D laboratory that bears his name today. Draper is best known for designing and developing guidance, navigation, and control systems for the Apollo lunar missions and nearly all of the nation's strategic missile systems.

## Strategic Systems



Draper is contributing its expertise in guidance, navigation, and control (GN&C) to maintain, modernize, and advance Navy and Air Force strategic missile guidance capabilities. For almost 50 years, Draper has been an essential part of the Nation's strategic defense through the Navy's Fleet Ballistic Missile Program, serving as the design agent for the weapon system's inertial guidance systems. Draper continues to perform this critical role in the design of the MK6 Life Extension (MK6LE) guidance system, and is applying its expertise to other areas of strategic defense.

### **MK6 Life Extension Overview**

As Prime Contractor for the Navy's Trident MK6LE, Draper oversees the entire development team as it modernizes the missile's inertial guidance system, extending its life to the year 2042 while lowering the Navy's future maintenance and support costs and providing a flexible architecture. We also continue to support and maintain the MK6 guidance system currently deployed in the Trident fleet.

Draper is employing sophisticated modeling and simulation techniques to verify designs well in advance of fabricating production hardware. These models are integrated into a virtual guidance system to provide stimulus to subsystem prototypes to verify their designs. Throughout the development process, Draper is conducting extensive testing to ensure high reliability and accuracy of the system.

## **MK6 Life Extension Cost Reduction**

Draper has minimized program costs by reusing high durability components from MK6, implementing a modular design of system electronics, and creating a system architecture designed to support future program requirements and alternative mission platforms. Draper has partnered on common design efforts with Lockheed Martin, the Navy's prime contractor for MK6LE electronics.

As systems integrator, Draper is responsible for all aspects of guidance system repair, consolidating all repair activities to a single Integrated Support Facility (ISF) in Pittsfield, Mass. Managed by Draper and operated by a General Dynamics/Raytheon team, the ISF provides full capability for inertial measurement system and guidance system electronic repair as well as the ability to support tactical hardware repair and a full spectrum of environmental testing.

## **Advanced Inertial Instrument Technology for Strategic Applications**

Draper is developing new designs for critical inertial sensors. The Alternate Pendulous Integrating Gyro Accelerometer (PIGA) and the solid-state Interferometric Fiber-Optic Gyroscope will replace older, more complex electromechanical inertial sensors that required many small, precision parts in a complex assembly. Also, a charged coupled device to be used in the MK6LE stellar camera is being developed in conjunction with e2v Corporation.

Draper continues to research and develop future strategic-grade inertial instrument technology. Development efforts include MEMS-based inertial instruments, cold atom interferometry, and a Zero Force Accelerometer.

## **Maintain Minuteman III to 2030 and Beyond**

Draper is performing accuracy and reliability analyses and addressing parts obsolescence for the Air Force's Minuteman III PIGA accelerometer.

## **Conventional Prompt Global Strike Development Support**

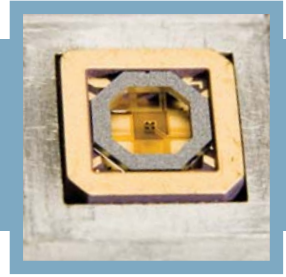
For a future Prompt Global Strike (PGS) technology designed to rapidly and accurately deliver conventional payloads anywhere on the globe, we are developing and testing navigation software for conventional reentry

vehicles and are conducting experiments with sponsors to demonstrate the technologies needed for PGS. Draper also has developed software and algorithms to provide accurate target and trajectory information in support of a web-based mission planning tool.

### **Trident Submarine (SSBN) Security**

Draper is developing improvements to the Navy's Transit Protection System (TPS), the system of autonomous twin boats that escort and protect each surfaced Trident submarine along its routes to and from port. We are evaluating the Dynamic Positioning Software used to control the positioning of the TPS escort boats, serving as independent reviewer of the software, supporting trouble-shooting, and evaluating performance. We have also contributed simulation-based improvements, supported test planning exercises, and participated in related experiments.

## Tactical Systems



Draper is applying its strengths to meet the critical needs of the U.S. military for advanced tactical systems. Key applications include soldier systems, GN&C for munitions and missile defense, autonomous systems for maritime applications, and closed-loop planning and control for command and control systems.

### Missile Defense

Draper is a trusted agent for GN&C expertise across the Missile Defense Agency (MDA). Currently, Draper is supporting the recently established MDA Knowledge Centers. A Draper staff member serves as the technical director of the MDA Space Knowledge Center. In addition, Draper continues to support the agency in advanced R&D initiatives; the most recent activities involve R&D for the space layer and advance agile systems for boost and reentry intercept. Finally, Draper is leading efforts to develop commonality standards for the wide array of layered weapon systems to reduce development cost and provide greater efficiency in supporting fielded systems.

### Maritime

Draper is developing intelligent autonomy algorithms to accomplish the Navy's goal of executing missions by multiple, heterogeneous teams of

unmanned air, surface, and undersea vehicles. Draper recently completed a 4-year effort composed of eight demonstrations, the first five of which were in simulation, and the final three combined simulation and in-water demonstrations. Draper has been developing an autonomy architecture and demonstration software package for the Unmanned Undersea Vehicles Program Office. The goal is a unified modular autonomy module based on open architecture software for use on all unmanned underwater and surface vehicles.

## **Precision Weapons and Delivery**

Draper is developing low-cost guidance electronics and GN&C software for the Navy's Extended Range Guided Munition (ERGM) and Ballistic Trajectory Extended Range Munition (BTERM) and the Army's Excalibur 1B programs.

Draper developed the BTERM Low-Cost Guidance Electronics Unit, which has successfully guided the Raytheon Ex-171 ERGM as well. The tests demonstrated new maximum range and precision impact levels for each projectile type and established a world record for guided gun-launched munitions performance. [*GPS World*, Vol. 16, Issue 9]

## **Soldier Systems**

Under the auspices of the U.S. Army's Natick Soldier Systems Center, Draper has been developing advanced guidance and aircraft mission planning and parafoil GN&C software for operations on C-130 and C-17 airdrop systems. The Joint Precision Airdrop System's (JPADS) guided-parachute supply delivery system, designed to reduce the risk to troops during resupply missions, made its first combat mission in Afghanistan in 2006. US forces routinely use JPADS for missions in volatile arenas.

Also for the Natick Soldier Systems Center, Draper has been developing the Precise Positioning System (PPS) for tomorrow's Objective Force Warrior. The PPS provides highly accurate position information in the presence of urban multipath, tree canopy attenuation, and for up to 15 minutes when GPS is unavailable, such as in buildings.

## **Command & Control**

Draper is applying mission planning and human systems collaboration expertise to DARPA's Joint Air to Ground Unified Adaptive Replanning (JAGUAR) program. We are conducting integrated planning and execution for strike and intelligence, surveillance, and reconnaissance operations for the program. By bringing all the functions of combat operations, including target identification, assessment, and information management, together in a single planning architecture, Draper offers significant improvement in efficiency for Air Operations Center activities.

Our latest foray is development of the Commander's Course of Action tool. This tool allows a commander to sketch out battlefield movements that the tool captures in software and inputs to a simulation. The simulation allows the commander to assess alternative courses of action before committing forces.

Finally, Draper is providing test support to the Air Force GPS Wing. We are providing detailed signal testing for GPS modernization efforts, and in the near future, independent testing of new ground control systems for the GPS constellation.

## Space Systems



Draper's Space Systems focuses on providing technology and solutions to the Nation's space programs. The organization's long heritage in space dates back to the early 1960s when Draper Laboratory (then known as the MIT Instrumentation Laboratory) played a pivotal role in developing the GN&C systems for the Apollo program. Draper continues to support NASA in space exploration programs and is one of the key technical organizations working on returning humans to the moon through NASA's Constellation Program. The Laboratory also has been working with the Department of Defense (DoD) since the early 1960s on numerous programs in first-of-a-kind hardware and software for both on-orbit and ground systems.

### Human Exploration

Draper is supporting NASA in the completion of the International Space Station (ISS) by 2010. Additionally, Draper algorithms control the Space Shuttle when it is docked with the ISS to perform an orbit reboost operation. As part of the Project Constellation team, Draper supports the development of the next generation of human exploration vehicles—the Ares I Crew Launch Vehicle, the Orion Crew Exploration Vehicle, and is the key member of the NASA Autonomous Landing and Hazard Avoidance Technology team. We are also developing the avionics system architecture, fault-tolerant flight computer prototypes, and the GN&C system architecture for the Ares I launch vehicle.

## **Military Space**

As the DoD increases its emphasis on developing advanced space capabilities, Draper is providing key mission concepts and technologies. Draper is working with the DoD on projects to mitigate threats to space-based operations through improved space situational awareness and a method of obtaining a comprehensive understanding of space events, threats, activities, conditions, and space system capabilities. Draper also is expanding its role from traditional GN&C to enhanced decision-making systems for space command and control operations centers.

## **Space Science, Earth Science, and Planetary Exploration**

Draper is actively working with leading local and national scientists across the U.S. to help solve critical problems and to develop advanced systems in Earth Science, Space Science, and Planetary Exploration.

Draper has started the development of the first U.S. based miniature ultra-sensitive accelerometer, the Zero Force Accelerometer (ZFA), which would greatly enhance the performance of the gravity measurement mission. The ZFA will bridge the domestic technological gap in ultra-precise accelerometers needed for NASA's Earth Science Decadal Survey.

Draper's Earth Phenomena Observing System (EPOS) mission planning software became fully operational for the EO-1 spacecraft in 2006. Draper's EPOS software autonomously reprioritizes the instrument target list that is compiled from conflicting requests by the EO-1 science team. EPOS evaluates the information and, if appropriate based on weather data and cloud prediction algorithms, automatically switches to a secondary target due to cloud cover.

Funded by NASA, Draper designed and built the Inertial Stellar Compass (ISC) payload launched aboard the U.S. Air Force TacSat-2 satellite to demonstrate the first microelectromechanical systems (MEMS) gyro in a fully integrated space navigation instrument. Combining Draper's MEMS gyro package with a star camera and processor, the ISC outputs spacecraft attitude at up to 5 Hz in a low-power (<4 W) and low-mass system (<3 kg) system.

## Special Operations



Draper's Special Operations Directorate is dedicated to improving the government's capabilities in the areas of reliable intelligence and Special Operations. Our programs focus on developing technology and systems involved with surveillance, counterterrorism, and homeland defense.

### **Sensors, Processing, and Exploitation**

Optimized coordinated tasking of existing assets maximizes the amount of intelligence that can be collected without requiring system modification. Collaboration among different intelligence organizations, the armed forces, and our allies is vital to maintaining an accurate, detailed representation of the world and anticipating future events. Draper provides advanced system utilization algorithms, networking architectural analysis, and software and hardware prototypes to extend the reach of users around the globe.

Draper also specializes in the area of exploitation systems. These systems investigate data temporally as well as spatially. Known also as Measurement and Signature Intelligence systems, they are exceptionally suited for detecting changes or attempts at deception. Draper has several IR&D projects in

this area including, one using hyperspectral sensing for target detection, classification, and material identification. Another includes monitoring air traffic patterns for abnormal deviations. We also are analyzing multilook synthetic aperture radar imagery to improve automatic target recognition as part of our Object-Level Change Detection IR&D project.

## **Delivery Systems**

Draper continues to develop small robotic systems for surveillance and rescue applications, including precision airdrop systems, small undersea vehicles, bio-mimetic air vehicles, and vehicles designed specifically to overcome difficult mobility challenges. These capabilities will allow our forces to be effective while avoiding hazardous or inaccessible environments.

## **Draper's Recent Robotics Work Includes:**

- Compact navigation sensors for robots, including the use of Light Detection and Ranging and gimbaled MEMS.
- Vision-aided navigation algorithms for controlling robotics without traditional navigation components such as GPS.
- Microactuator research with series elastic actuation, volume, and weight efficient harmonic drives, and magnetorheologic fluids as a means of controlling hydraulic valves;
- High-Mobility Tactical Micro-robot system, a small lightweight reconnaissance robot that has a tracked and articulated vehicle architecture for rough terrain operation and an accompanying Personal Data Assistant- based user interface. Other features include robust wireless links over Wi-Fi and cellular networks, image processing to support video stabilization, and moving-target tracking capabilities.
- Developing the microavionics system for a miniature class of Unmanned Aerial Vehicle called the Nano Air Vehicle, which is designed to fly both indoors and outdoors and operate in challenging urban environments. The ultimate goal is to create a vehicle that weighs less than 8 grams, is smaller than a 3-inch sphere, and can carry a 2-gram payload. Draper is working to develop a propulsion subsystem, guidance and navigation subsystem, communications subsystem, video subsystem, and power supply to fit within that small package.

## **Vanishingly Small Systems**

Draper is combining miniaturized electronic assemblies, reduced footprint antennas, and energy management solutions, including research in paper-thin power sources, to develop ultra-miniature systems to support close-in collection operations.

## **Small, Low-Power Electronics**

Draper maintains a leading role in developing very small, low-power electronics with a broad range of potential applications for special operations. We continue to pioneer multichip-module (MCM) technology for ultra-compact electronics packaging, including developing novel methods for employing mixed-signal components in this technology, and have demonstrated unprecedented levels of miniaturized system integration.

## **Microelectromechanical Systems**

Draper continues to be leader in MEMS. A key use of MEMS is miniaturized inertial navigation and guidance systems. Draper continues to develop new processes and employ the latest state-of-the-art manufacturing equipment to ensure high yields of its MEMS devices.

## **Integrated Ultra High-Density Packaging**

Draper continues to leverage its MCM and MEMS capabilities to further reduce the size, weight, and power of electronic assemblies by developing 3D integrated packaging techniques.

## **Flexible Circuits**

Draper has developed technology to create silicon and circuit boards that are as thin as tens of micrometers. This allows the circuit to flex yet remain operational.

## Biomedical Engineering



Exploiting the synergy between engineering and the life sciences, Draper is working on some of today's most critical health care problems in partnership with leading medical and research institutions and pharmaceutical organizations to develop innovative diagnostics and therapies for clinical and defense needs.

Draper's initiatives include point-of-care diagnostics, drug delivery, tissue engineered organs, biodefense, tools for discovery; and our technology development is focused in the areas of sensors and instrumentation, BioMEMS, microfluidics, and image analysis and signal processing.

Current collaborators include clinicians and researchers at Massachusetts General Hospital, Brigham and Women's Hospital, Beth Israel Deaconess Medical Center, Johns Hopkins, the College of Medicine at the University of South Florida, and Tufts Medical School. We are also collaborating with engineering colleagues at MIT, Tufts, and Northeastern University.

## **Implantable Therapeutics**

Draper's MEMS technology offers promising solutions for organ replacement and implantable therapeutics. Our 3D MEMS structures are enabling artificial organ development by minimizing blood clotting, maintaining cellular phenotype, efficiently distributing oxygen, and filtering toxins from these systems.

Draper's MEMS technology also is showing promise as a new platform for human tissue models for early stage high-throughput drug screening for evaluating the safety and efficacy of new compounds earlier in the drug development process.

## **Point-of-Care (POC) Diagnostics**

Four technologies being developed at Draper hold potential for rapid POC diagnostics: breath analysis, MEMS chemical/biological sensing devices, nanohole array sensing, and optical nanosensors.

Certain diseases manifest themselves in a person's breath. While researchers have advanced the science of breath analysis of cardiac problems, diabetes, and other diseases, no products are readily available or suitable in size or simplicity to aid such diagnoses. We have simplified and miniaturized the detection and means to detect tuberculosis. Using our technology partner Sionex's ion mobility spectrometer, we are developing a handheld device small enough to fit in a shirt pocket, accurate enough to detect emissions from bacteria in the lung, and cost effective enough for use with patients in the Third World. Most importantly, it can detect the disease in minutes.

Our continued refinement of MEMS has led to the development of a number of successful sensors, such as Adhesive Stress Electrostatic Sensor, a small sensor capable of detecting minute amounts of chemical or biological material. Current applications are being developed to detect tuberculosis and other infectious diseases. Its small size will make it competitive with other low-cost detection technologies, yet it offers increased benefits in improved consistency and accuracy.

Our smallest sensor is nano in size – so small it can fit benignly within a living cell. These sensors are being developed to assist pharmaceutical companies in evaluating new drugs. Implanted within human skin, they will be used to revolutionize the methods for continuous monitoring of blood, eliminating the need to acquire blood samples for analysis.

## **Medical Informatics**

Draper is integrating and applying its technologies in image analysis, signal processing, data mining, and visualization to create highly effective medical information systems. These systems are of value to researchers in automatically analyzing cellular behavior, clinical trial managers looking for adverse affects of therapies in human subjects, and physicians looking for trends indicating the onset of illness. Such powerful tools are advancing the extraction of valuable medical information in a timely manner.

## Energy Solutions



Energy is universally recognized as a major challenge for the nation in the coming years. Addressing the problem comprehensively utilizes both near-term solutions and the development of fundamental advances for the long term. Draper is employing its expertise in sensors and controls to develop low-cost technologies that will improve the efficiency, safety, and security of the nation's energy systems.

As the nation continues to scale up its use of alternative energy in the coming decades, efficiency improvements of traditional power sources will make the single most significant impact on greenhouse gas reduction. A 10% efficiency improvement for existing coal-based systems could reduce greenhouse gas by several billion tons a year.

We are working with several power companies to improve the efficiency of coal plants, which supply close to 50% of the United States' electricity, by using process monitoring and control to optimize combustion and plant efficiency. We are working closely with our partners to develop a real-time loss-on-ignition sensor that can be used to monitor combustion efficiency by spatially resolving regions within the furnace where combustion is not operating ideally. By integrating spatially-mapped carbon monoxide and oxygen sensors, we will be able to develop optimal control algorithms to increase burner efficiency and other plant systems.

The Laboratory also is working on optimizing traffic flow at intersections via a smart traffic grid. This will reduce carbon emissions from unnecessary motor idling, and improve public safety by enabling emergency vehicles to have a more efficient right of way.

Draper is researching techniques to aid in the proper integration of alternative energy systems into the nation's power grid. This will help ensure an uninterrupted supply of electricity as distributed energy sources are connected into the system.

Draper has also leveraged its extensive experience to assist the oil and gas sector to improve the supply side capabilities of our country. Our extensive experience in GN&C along with sensor technology can be applied directly to the directional drilling, down-hole sensing, telemetry, and other improvements that aid the efficient extraction of oil and gas. This improves the ability to recover these resources and will lead to lower energy costs.

# Geospatial Solutions



## Infrastructure, Management, and Dissemination

Draper's core competences in geospatial information management and the development of enterprise systems in the storage, retrieval, and analysis of geospatial information are helping sponsors develop future tools and systems for geospatial imaging. The Lab has an excellent foundation of technical practitioners dedicated to operational engineering and collaboratively working with government customers to identify needs and solve difficult problems in geospatial information management facing the defense and intelligence community.

## Geospatial Product Library

Draper's Geospatial Product Library (GPL) was the first step to address the DoD's Geospatial Transformation Plan that mandated a migration to a fully digital centric environment by the year 2010. First conceived to consolidate regional map data on a single appliance server to support military and warfighter operations in Kosovo, the GPL is supporting worldwide data sets and is backed by an infrastructure of hardware and software hosted at various levels in the military services command. The GPL architecture provides features that simplify human interaction through the use of automation. The user-friendly and low-cost benefits of GPL have found their way to more than 100 military sites worldwide.

## **Enhanced Geospatial Product Library**

Government sponsors have funded an effort to enhance the GPL for use in joint military environments. For this effort, Draper is developing a capability to ensure that joint military operations are planned and executed using a single, up-to-date, and authenticated set of geospatial products.

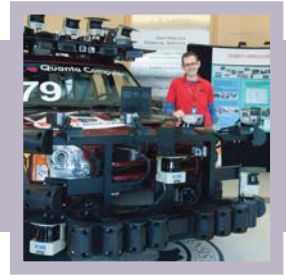
## **Enterprise Geospatial Data Servers**

Draper also is supporting the design, construction, and installation of geospatial data servers and data storage devices. The servers will provide the customers a means to acquire, organize, manage, and present spatial data, products, and services. As part of these efforts, we have developed and implemented a data management plan to address data usability issues relevant to intelligence analysts, Draper is also developing spatial data dissemination mechanisms to support interoperability.

## **Center of Excellence for Geospatial Solutions**

Draper Laboratory and George Mason University have established a Center of Excellence for Geospatial Solutions for enabling effective creation, analysis, exploitation, and management of geospatial information through advanced technology exploration and development. This Center combines the advanced engineering capability of Draper Laboratory with the geospatial research and education strengths of George Mason University.

## Independent Research & Development



### Independent Research & Development

Draper's IR&D investments serve a variety of important purposes related to program, technology, staff, and process development. Of primary importance is the development of novel system concepts and technology discriminators in anticipation of our sponsor's near- and far-term needs. The Laboratory is currently investing over \$25 million in IR&D projects in several application areas. These projects support the Lab's strategic plan through investment in internal research projects, university research grants, corporate thrusts, and seedling concepts.

### Draper Seedling Program

Designed to fuel the innovative spirit at the Lab, Draper seedlings are small research projects of 3-6 months in duration that enable researchers to explore an "out-there idea" or mature a concept that would be of value to Draper's long-term strategy. Seedlings explore the unknown and use technology in new ways. When successful, they can grow into larger programs, either Draper IR&D projects or sponsor-funded projects.

### DARPA Urban Challenge

In 2007, DARPA's Urban Challenge pushed the boundaries of fully autonomous vehicle research. Robotic vehicles were required to obey

intersection rules, merge across traffic, pass moving and stationary cars, and even park in designated spaces – all while visiting specific waypoints in small town road network. Each vehicle was tasked to complete 60 miles of completely autonomous safe driving in a mixture of human driven and robotic traffic.

Draper joined with MIT to design and build a vehicle for the Challenge. Draper engineers helped with developing the project requirements and evaluating the many paths for building a robotic system of this complexity. We consulted on navigation system options, designed the vehicle states and modes, and led the vehicle system integration and test efforts. Our team successfully passed the Qualifier Events in Victorville, Calif., and was one of only 11 teams to compete in the final Race Event, ultimately placing fourth of five vehicles to finish the Urban Challenge. For more information, visit <http://grandchallenge.mit.edu/>.

### **Precise Inertial Sensing**

Atom interferometry inertial sensing using ultra-cold atoms has been demonstrated in university laboratories and is starting to migrate into field deployment. The first applications for cold atom inertial sensors are likely to use very high-performance, meter-sized instruments deployable only on large platforms such as trucks, large aircraft, ships, or submarines. Draper is looking to expand the range of applications of cold atom inertial sensors to smaller platforms using smaller instruments. Draper is collaborating with Prof. Mara Prentiss at Harvard University to further develop enabling technologies for cold atom inertial sensing. We maintain a broad interest in novel inertial sensor physics, including examining inertial sensors using laser-levitated dielectric particles.

### **First Responder Navigation**

Draper has developed image-aided navigation software that has been tested on small Unmanned Aerial Vehicles (UAVs) and cell phones. This technology has been a key enabler for our Nano-UAV efforts where severe payload weight limitations do not allow traditional navigation sensors and electronics to be used. By utilizing imagery from the onboard payload camera, a few stationary, high-contrast objects in the camera's field of view are tracked – providing relative position and orientation change information to an Extended Kalman Filter.

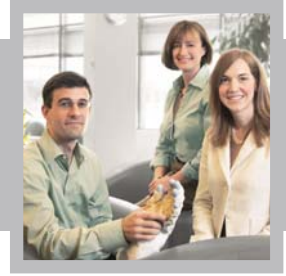
This software has been ported to a cell phone, running in real-time with the existing processor, imager, and image display. The use of image feature tracking provides very good low-drift navigation performance for this low-power and low weight system. As in any navigation system, without absolute navigation information, the estimates will drift over time. Therefore, automatic correlation of imagery with mapped landmarks is of interest to Draper. For a first responder on the ground or a small UAV flying at low altitudes, onboard camera images cannot be easily correlated to high altitude image maps, but by incorporating 3D georegistered maps like those of Google Earth, camera images taken from the ground can be automatically correlated using local geometric shapes, such as roof line geometries, even when seen from highly oblique angles. The result is an absolute navigation measurement signal that often is better than GPS signals as a position fix and a compass for orientation.

## **Human-Systems Collaboration**

Information exploitation, situation assessment, and decision-making for application domains ranging from operator interactions with autonomous vehicles to command and control for military air operations are typically both complex and time-critical, posing daunting challenges for operators of those systems. Draper has developed Human-System Collaboration (HSC) technology and methodology that ensure optimized interaction and collaboration between automation and the operator in addressing problems of this class. Building on Draper's ADEPT (All-Domain-Execution-Planning-Technology) approach, HSC research areas include:

- Context Estimation: developing situation understanding based on environment, mission and mental models.
- Immersive Interaction: adaptive interaction technology to reduce cognitive load and improve collaboration.
- Collaboration Mediation: enhancing the layers of person-to-person collaboration to increase shared situational understanding.

## Working at Draper



Working at Draper Laboratory offers engineers the chance to advance the state-of-the-art in their fields. As a research and development organization that emphasizes first-of-a-kind system design and development, Draper encourages creativity and ingenuity. Those traits are valued in the performance of both our sponsored work and IR&D projects.

In addition to challenging and exciting projects, working at Draper offers the opportunity to collaborate with highly skilled and talented colleagues. To help employees keep current, Draper supports professional development activities, including a generous tuition assistance program.

Innovation and accomplishment are rewarded in many ways. Draper Distinguished Performance Awards for exceptional achievement are presented to employees as individuals or teams at the Annual Meeting of the Corporation. The Vice President for Engineering presents annual awards for best paper, best patent, outstanding task leader, and student mentoring during National Engineers Week. Through a royalty-sharing program, employee inventors receive a share of royalties paid to Draper under licensing of the Laboratory's intellectual property.

**For information about joining the Laboratory's technical staff,  
visit [www.draper.com](http://www.draper.com) or contact**

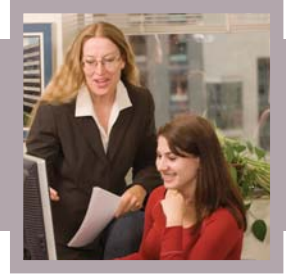
Greg Egavian at [gegavian@draper.com](mailto:gegavian@draper.com) or (617) 258-2885

Greg Welch at [gwelch@draper.com](mailto:gwelch@draper.com) or (617) 258-4188

Kevin Owens at [kowens@draper.com](mailto:kowens@draper.com) or (617) 258-3145

Kathyr Ranger at [kranger@draper.com](mailto:kranger@draper.com) or (617) 258-4343

## Draper Educational Programs



Draper's educational mission to promote and support advanced technical education is one of the four tenets of the Lab's organizational charter. Our education programs carry on the heritage that began when Doc Draper established a teaching laboratory at MIT. The Education Office administers our programs for University Research and Development (URAD) and student research and engagement.

### **URAD and Collaboration**

Through our annual URAD program, faculty researchers nationwide can obtain funding from Draper to advance key technical fields of knowledge. Approximately \$2.5M per year is distributed among about 25 different projects through a competitive selection process. In the 2008-09 fiscal year, over a dozen different universities, including MIT, UMass-Amherst, Vanderbilt, Harvard, and UC-Santa Barbara, are working on Draper-related research. In addition, our IR&D program engages university partners in collaborative research. The ultimate goal of these projects is to define and mature technologies sufficiently to engage an external sponsor for further development and use.

### **Graduate Student Programs**

The Draper Laboratory Fellow (DLF) program sponsors graduate student research at local universities, forming a 3-way partnership among a graduate

student, a local university faculty member, and a Draper staff member. Draper sponsors the student's graduate studies while the student completes his/her thesis research here at the Lab on a Draper-related project. Because of the need for 3-way cooperation and lab work, these positions usually require the student's home university be located in proximity to a Draper office site. Draper sponsors approximately 50 Master's and Ph.D. candidates each year.

## **Undergraduate Student Programs**

The Lab offers summer internship programs for undergraduates as well as part-time employment throughout the year. We also work with several local universities to sponsor co-operative education positions.

## **High School Internship and Research Programs**

Students from local public schools are engaged in summer internships, part-time employment during the school year, and school-based research projects. These programs are administered by Draper's Corporate Communications & Community Relations Office.

**For more information, contact [ed@draper.com](mailto:ed@draper.com).**



Sarah Rosenstein, an EECS undergraduate at University of Rochester, built and tested sensor technologies with her supervisor, Jeff Derderian, during her 2008 summer internship at the Lab.



Erin Swan, a Ph.D. candidate at MIT, is working with supervisor Mark Mescher, developing a microfluidic drug delivery device.

**The Charles Stark Draper Laboratory, Inc.**

555 Technology Square  
Cambridge, MA 02139-3563  
617.258.1000  
www.draper.com

Business Development  
busdev@draper.com  
617.258.2124

Washington  
Suite 501  
1555 Wilson Boulevard  
Arlington, VA 22209  
703.243.2600

Houston  
Suite 470  
17629 El Camino Real  
Houston, TX 77058  
281.212.1101

Huntsville  
Suite 225  
1500 Perimeter Parkway  
Huntsville, AL 35806  
256.890.7392

Tampa  
Draper Bioengineering Center at USF  
3802 Spectrum Boulevard  
University of South Florida  
Tampa, FL 33612  
813.972.4626

St. Petersburg  
9900 16th St N  
PO Box 22369  
St. Petersburg, FL 33742-2369  
727.235.6500

