Commercial Success Stories

While NASA utilization is one objective of the SBIR and STTR programs, another, equally important goal, is that of developing commercially viable products based on the technologies developed through SBIR research. The following stories highlight technologies developed at least in part through NASA SBIR and STTR contracts which have evolved into products that could touch all our lives.

Refrigeration System Additive

In the late 1980's, Mainstream Engineering received an SBIR award from Goddard Space Flight Center to develop a chemical and mechanical heat pump. As an indirect result of that effort, Mainstream developed QwikBoost™, an additive for vapor-compression refrigeration systems, air conditioners, and heat pumps that increases system performance and consequentially reduces overall energy consumption.

In essence the additive works by increasing the cooling capacity of the refrigerant. The additive circulates through the refrigeration system similar to the way the lubricant circulates. It has a high affinity for liquid hydrofluorocarbon and hydrochlorofluorocarbon refrigerants and exhibits a significant heat of solution when mixed with them. This solution heat increases the available cooling capacity (latent heat) of the refrigerant during evaporation, which provides an increase in performance of the system.

The additive has been shown to be environmentally safe with zero ozone depletion potential and has been shown to improve the performance of vapor-compressor heat pumps, air conditioners, and refrigeration systems by as much as 20 percent. Additionally, the additive remains active for the life of the system and does not need to be replaced once it is introduced into a system.

NASA and other government applications are numerous, including vapor-compression thermal control systems for spacecraft, which result in lower mass systems, and hence lower launch costs. The product is also in use in air conditioning and refrigeration systems at NASA facilities, which results in annual energy savings.

Chemical heat pump being added to a system.

Photodynamic Therapy

In the mid-1990's, Quantum Devices of Barnveld, Wisconsin, began working with the Marshall Space Flight Center (MSFC) through the SBIR program to develop plant growth technology for Space Shuttle experimentation. Quantum Devices' focus was on photodynamic therapy or PDT. The company developed a compact, highly reliable light source for PDT: a light-emitting diode (LED) probe. The company has since applied this technology for medical applications—specifically cancer treatment and wound healing.

In its work in cancer treatment, Quantum Devices uses its LED probe to activate photosensitizers—light sensitive, tumor treating drugs. The LED activation process allows the drugs to destroy cancerous cells and leave the surrounding, healthy tissue virtually untouched. While lasers have been used for this type of treatment, the LED probe has been shown to have significant advantages.

Compared to lasers, the LED has proven to be more mechanically reliable. It is also smaller—the whole system is about the size of a briefcase—and is less expensive to use. In terms of improved medical effectiveness, the LED probe produces a longer wavelength, broad spectrum, near-infrared light that allows for wider and deeper penetration of the drug therapy.

The positive results achieved by Quantum Devices have led the company to start obtaining the necessary approvals from the Food and Drug Administration (FDA) for more widespread usage. Currently, the probe is approved for use in certain cases where all other methods of treatment have been exhausted. In addition, cancer treatment trials are underway.

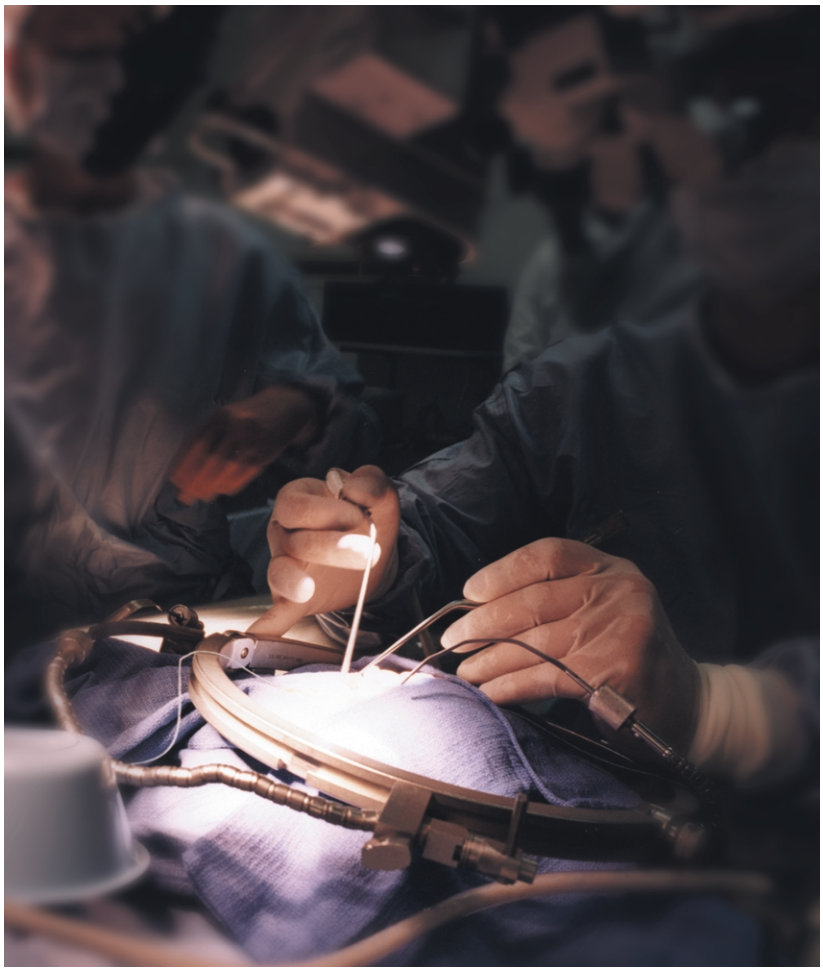
Results to date have been very positive. For example, in May 1999, a young woman with an aggressive form of brain cancer was treated with a photosensitized chemotherapy drug that was then activated by the LED probe. She has since fully recovered from the operation and there is no evidence of the tumor returning. Prior to the LED operation, this patient's 10-year battle with the cancer had included six surgeries, chemotherapy, and radiation treatments.

Quantum Devices has recently expanded LED-based treatments to the area of wound healing. NASA has an interest in wound healing because wounds are slow to heal in a microgravity environment. As in the case of cancer treatment, laser-based wound healing has been investigated, and again, the LED-based therapy has been shown to be an effective alternative. Lasers possess problematic characteristics that the LED does not, including limitations in wavelength and beam width. In addition, larger wounds can be treated with flat arrays of LED's.

NASA and Quantum Devices are currently engaged in a phase II SBIR contract to further the study of wound healing with the LED-based technology. One of the objectives of this work is to undertake human clinical trials.

While the medical applications of the LED technology are very exciting, it should also be noted that the original objective of the work for NASA has also been successful. Plant growth is essential to long term space habitation, and Quantum Devices' LED has flown on multiple Space Shuttle

Light-emitting diode (LED) probe used in the photodynamic therapy treatment of cancer.



Applying light-emitting diode (LED) technology to heal wounds.

missions inside the Astroculture™ plant growth chamber. Quantum Devices' work with LED's is a great example of how SBIR developed technology can have benefits not only for NASA but also for the Nation.

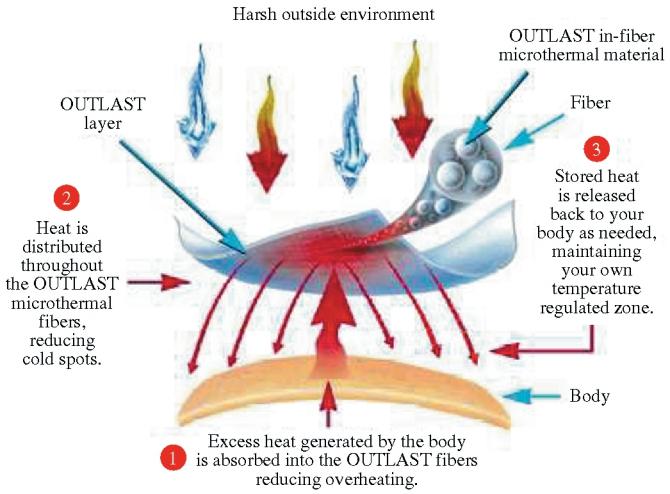
Phase Change Material for Insulation

Due to the 400-degree difference between light and shadows on the moon, NASA needed an innovative thermal regulation system that could significantly out perform traditional lofted insulation. The technology developed—called phase change material or PCM—was the outcome of SBIR-sponsored work.

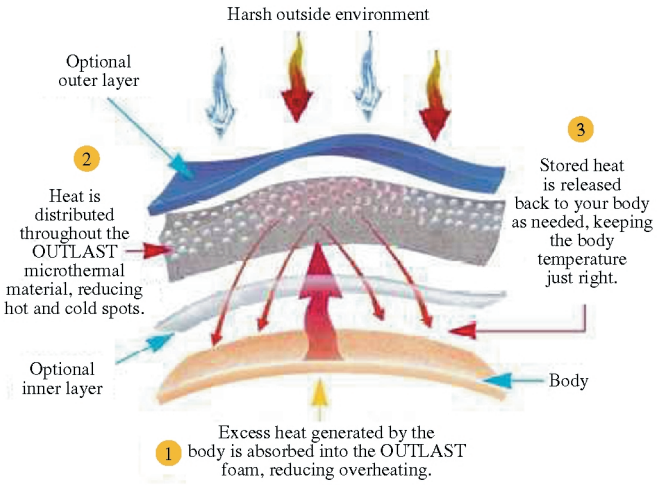
This technology was developed for NASA through an SBIR contract with Triangle R&D Corporation in conjunction with Johnson Space Center. In 1991, exclusive license to this technology was granted to OUTLAST from Triangle R&D Corporation. Since that time, OUTLAST has partnered with over 150 manufacturers and suppliers to market the product.

The PCM is essentially a nontoxic paraffin wax that is encapsulated in a plastic shell. PCM's are microscopic in size—thousands fit on the head of a pin. The paraffin wax changes from a liquid to a solid state, and back again, due to changes in temperature, which allows storage and recycling of body heat. The PCM's exchange large amounts of energy (heat) during this process. This exchange process happens continually and allows the user to maintain a fairly constant body temperature over a broad range of environments and exercise levels. PCM's can be applied to fibers, fabric, and foam, making it very versatile. Current applications include a wide variety of gloves, boots, jackets, and blankets.

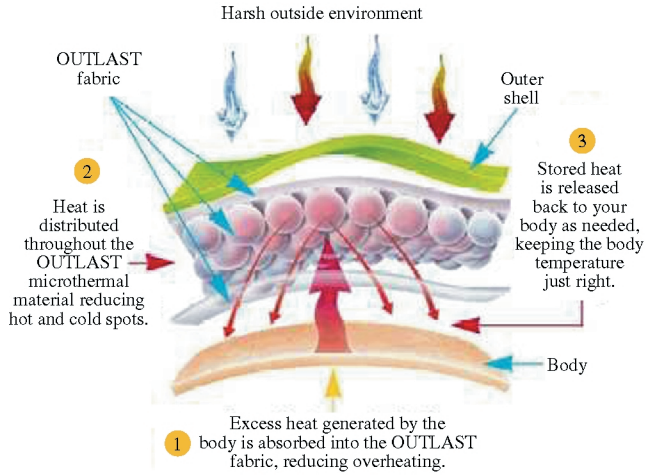
OUTLAST is proud to be a member of the NASA-sponsored U.S. Astronaut Hall of Fame in recognition of flight gloves made from PCM material. Ski equipment made from PCM material was voted Best Innovation for the New Millennium by *Skiing* magazine and was also included as one of the best products of 1999 by *Business Week* magazine (Dec. 20, 1999).



Phase change material used in fiber.



Phase change material used in foam.



Phase change material used in fabric.

Robotic Surgical Assistance

Computer Motion, Inc. of Goleta, California, has developed, with the assistance of two SBIR contracts from the Jet Propulsion Laboratory (JPL), a suite of computer enhanced and robotic surgical assistance systems. Studies have shown that these systems not only enhance the surgeon's capabilities, but also improve patient outcomes and reduce costs.

JPL's first SBIR contract with Computer Motion supported the development of the automated endoscopic system of optimal positioning or AESOP. In endoscopic procedures, a thin probe called a laproscope with a miniature camera attached is surgically placed inside the patient. This allows the surgeon to view the surgical field on a television monitor. The AESOP positions the laproscope where the surgeon wants it. Prior to the development of AESOP, a surgical nurse would position and hold the laproscope. By using AESOP, the surgeon can control the laproscope directly and the naturally occurring unsteadiness of the human hand is eliminated.

In 1995, AESOP received approval from the Food and Drug Administration (FDA). In many hospitals it is now routinely used

for gall bladder operations, hernia repair, and other laproscopic-based surgeries.

A second SBIR contract with JPL allowed Computer Motion to demonstrate a number of important enhancements to AESOP. There were three improvements that the SBIR contract contributed to: additional robotic manipulators or arms that are controlled by the surgeon, the ability of the surgeon to use voice commands to control the position of the laproscope, and finer controls of the robotic arms. The finer control mechanisms allow for the filtering out of tremors to the level of steadiness necessary for microsurgical suturing.

These improvements have been incorporated into a new device called ZEUS. The ZEUS has three interactive robotic arms, a computer controller, and a console. Using ZEUS, the surgeon is situated at the console to control the movements of two of the robotic arms that perform the procedure. The console includes handles, resembling conventional surgical instruments, that are used to control the robotic arm movement of the actual surgical instruments. The third arm provides the surgeon with voice controlled visualization of the procedure.

Both AESOP and ZEUS have been applied to heart surgery. Computer Motion has recently completed three clinical series totaling more than 300 minimally invasive mitral heart valve surgeries with AESOP. The AESOP system allows the surgeon to perform these operations though a small incision (4 to 6 cm) rather than fully cutting open the chest. The AESOP endoscope provides the surgeon with a clear, motionless view of the surgical area, which the trials showed lead to a significantly (approximately 20 percent) reduced operation time. The smaller incision also results in faster recovery times for patients.

ZEUS is also pushing the envelope for heart surgeons. It completed, in the spring of 2000, an FDA-approved phase 1 investigational device exemption study. At the London Health Sciences Center in Ontario, Canada, several patients have benefited from ZEUS. In those cases, the patients have undergone beating heart bypass surgeries. Previously, all bypass patients were put

Robot Surgical System (ZEUS™).

on a heart-lung machine during their surgeries, but with ZEUS, surgeons have been able to perform the necessary work while the heart is still beating and pumping blood.

While still very much in the trial stages, the ZEUS technology holds promise for vastly improving patient results in specific types of bypass surgeries. The ZEUS removes two of the elements of the procedure that greatly affect recovery time —the large incision and the trauma to the chest that goes along with it and the use of the heart-lung machine. Patients who had this experimental bypass procedure reported that they had minimal pain after the surgery and some were able to return to work with in a week.

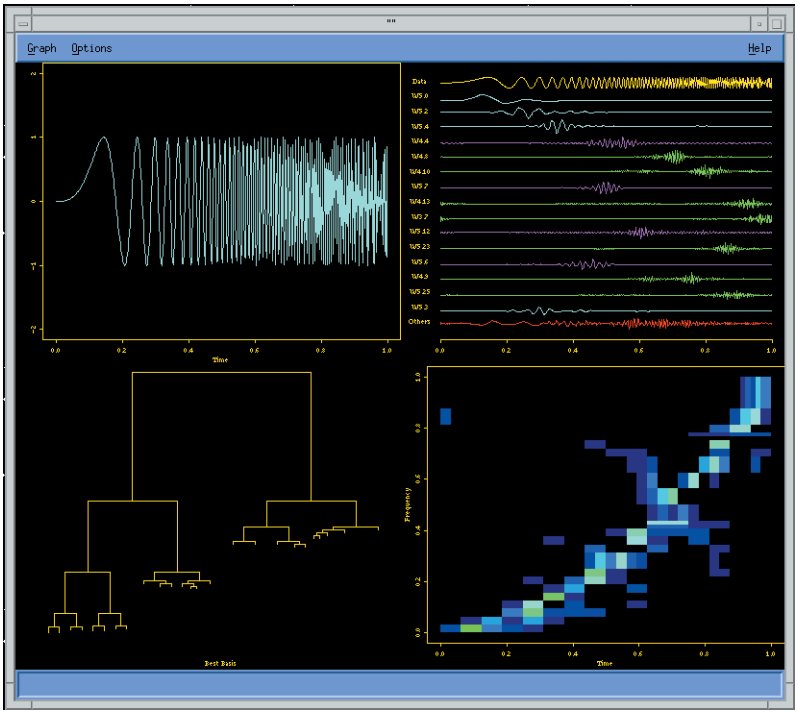
Wavelet Analysis

Wavelet analysis is a growing area of focus in the mathematical and research communities. The study of wavelets as a distinct discipline began in the late 1980's.

Wavelet analysis is the use of linear combinations of wavelet functions to represent signals. These representations are very useful for a broad range of data analysis applications such as data compression, signal and image processing, and nonparametric statistical estimation.

Wavelet analysis has some significant advantages over more traditional methods such as Fourier analysis. For example, wavelets are localized in time. They are good building block functions for many types of signals, including those that have jumps or other non-smooth traits, which are not well suited to Fourier series approximations.

As the field of wavelet analysis became more developed, the need for a package that included all of the utilities of wavelet functions in one collection increased.



This screen demonstrates the best wavelet packet analysis of a quadratic chirp signal using S+ Wavelets software.

Addressing that need was the objective of an SBIR contract that the Stennis Space Center awarded to the StatSci Division of Mathsoft, Inc. StatSci developed, with the assistance of the SBIR contract, the first commercially available computer software application that provides users with a comprehensive wavelet analysis toolbox. The product is called S+Wavelets. S+ Wavelets software offers the user more sophisticated methods of analysis; users can view and explore details in data that other techniques may miss or lose.

S+Wavelets software was designed to be an add-on module to the company's popular S-PLUS software program, which is one of the most powerful data analysis packages available. Scientists, data analysts, and engineers who use S-PLUS software can add S+Wavelets software and have a more powerful tool. Since the initial release of S+Wavelets software, it has been modified so that now it can also be purchased as a module for Mathsoft's MathCad software. MathCad software is a mathematical and engineering package for personal computers.

In addition, a manual *Applied Wavelet Analysis with S-PLUS* was published through an SBIR contract with Stennis. This manual takes a visual approach to wavelet analysis with less emphasis on the mathematics and more on the actual uses of wavelet analysis.

Since its initial release in 1995, hundreds of copies of S+Wavelets software have been sold both in the US and worldwide. Thousands of copies of *Applied Wavelet Analysis with S-PLUS* have also been sold.

Water Analyzer

Applied Spectrometry Associates (ASA) Inc., a Waukesha, Wisconsin based company, is successfully commercializing water analyzers that were originally designed under an SBIR contract sponsored by the Kennedy Space Center (KSC).

The analyzer, known as ChemScan®, is a process analyzer that uses ultraviolet spectrometry and specially designed software to detect dissolved nutrients, organics, and metals in municipal or industrial water and wastewater plants. The system provides an online, real-time monitoring capability. Online management of the system can be managed either at the specific plant site or from a remote location.

Originally developed as a water chemistry analyzer to provide real-time monitoring of plant nutrients in hydroponic solutions for the KSC Biomedical Office, the ChemScan® analyzer can detect any chemical substance that absorbs light in the ultraviolet or visible wavelength range. The system can detect, identify, and quantify various macronutrients within the absorption spectra. Other innovative aspects of this water analyzer include its low maintenance; it requires only a few hours a month for calibration verification and preparation of reagents. No time is needed for recalibration. In addition, the system uses multiple wavelengths for analysis thereby allowing for the simplification of testing processes.

ASA purchased the manufacturing rights for the ChemScan® analyzer from Biotronics Technologies Inc., which had done the original SBIR-funded research. Commercial ChemScan® analyzers are used to measure multiple chemicals at water treatment or wastewater treatment plants. There are now four models of the ChemScan® analyzer. The newest model, released in 1998, provides automatic analysis of ammonia or phosphate in water.

Over 100 ChemScan® systems have been installed at industrial and municipal facilities, including multiple parameter systems in major U.S. cities such as Phoenix, Arizona; Austin, Texas; Los Angeles, California; Gainesville, Orlando, and Tampa, Florida; and New York City. ASA has also had international sales, including in Canada and South Korea.

Ring Buffer Network Bus

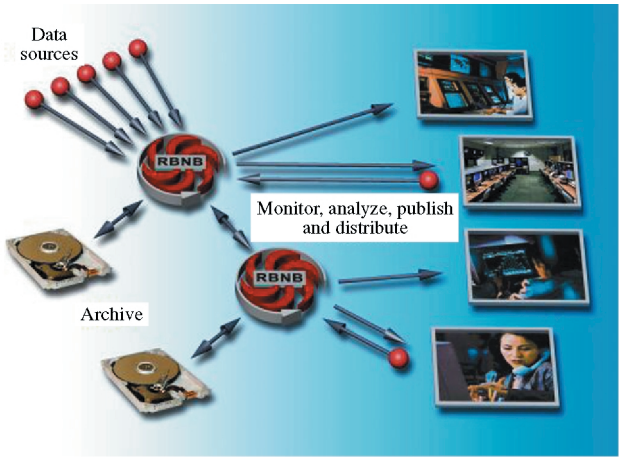
DataTurbine™ ring buffer network bus is a software server that was developed by Creare, Inc. of Hanover, New Hampshire in part through a SBIR contract with Dryden Flight Research Center. The DataTurbine™ server provides a buffered network data path between suppliers and consumers of information. It manages all aspects of interapplication data traffic, assimilating data acquisition, and network storage.

DataTurbine™ servers address the often conflicting problems of processing multiple data sources into a single data stream while providing fast, easy access to that data by many users. The software is a network data server that is inserted between the data sources and end users and manages data flows. DataTurbine™ servers enable real-time or request and response data exchange from point-to-point, one to many, or many to one sources.

DataTurbine™ servers enable remote monitoring, synchronized data distribution, application integration, and collaborative processing. In an initial NASA application, the ring buffer network bus (RBNB) software was set up in the Research Engineering Test Station (RETS) onboard an L-1011 aircraft to automate data analyses that previously could only be done after the flight was concluded. Engineers at Dryden were able to provide an immediate assessment of each aircraft maneuver as it occurred during the flight to test drag reduction technology.

Numerous DataTurbine™ servers are being used on the NASA DC-8 Airborne Science Flying Laboratory, the flight test mission control center, and remote sites at other NASA centers. Recently, an

Ring buffer network bus (RBNB) enables monitoring, data distribution, integration, and collaborative processing.



experiment, AeroSAPIENT, was conducted in the DC-8. This experiment was a collaborative effort between four NASA centers that explored the safety of, and data integrity of, digital aircraft communication systems for future aircraft.

Dryden's current contract with Creare can be used by any U.S. Government agency. Glenn Research Center is using the contract for developing a next-generation engine test stand, and the Force Protection Battle Laboratory at Lackland Air Force Base is using DataTurbine™ servers as part of a prototype distributed command and control system. Lastly, the Department of Energy and the Air Force have SBIR activities that include DataTurbine™ servers.

DataTurbine™ servers won an honorable mention in NASA's 1999 Software of the Year competition. In addition, the patent pending technology was recently presented with an R&D 100 Award for 2000 from *R&D* magazine.