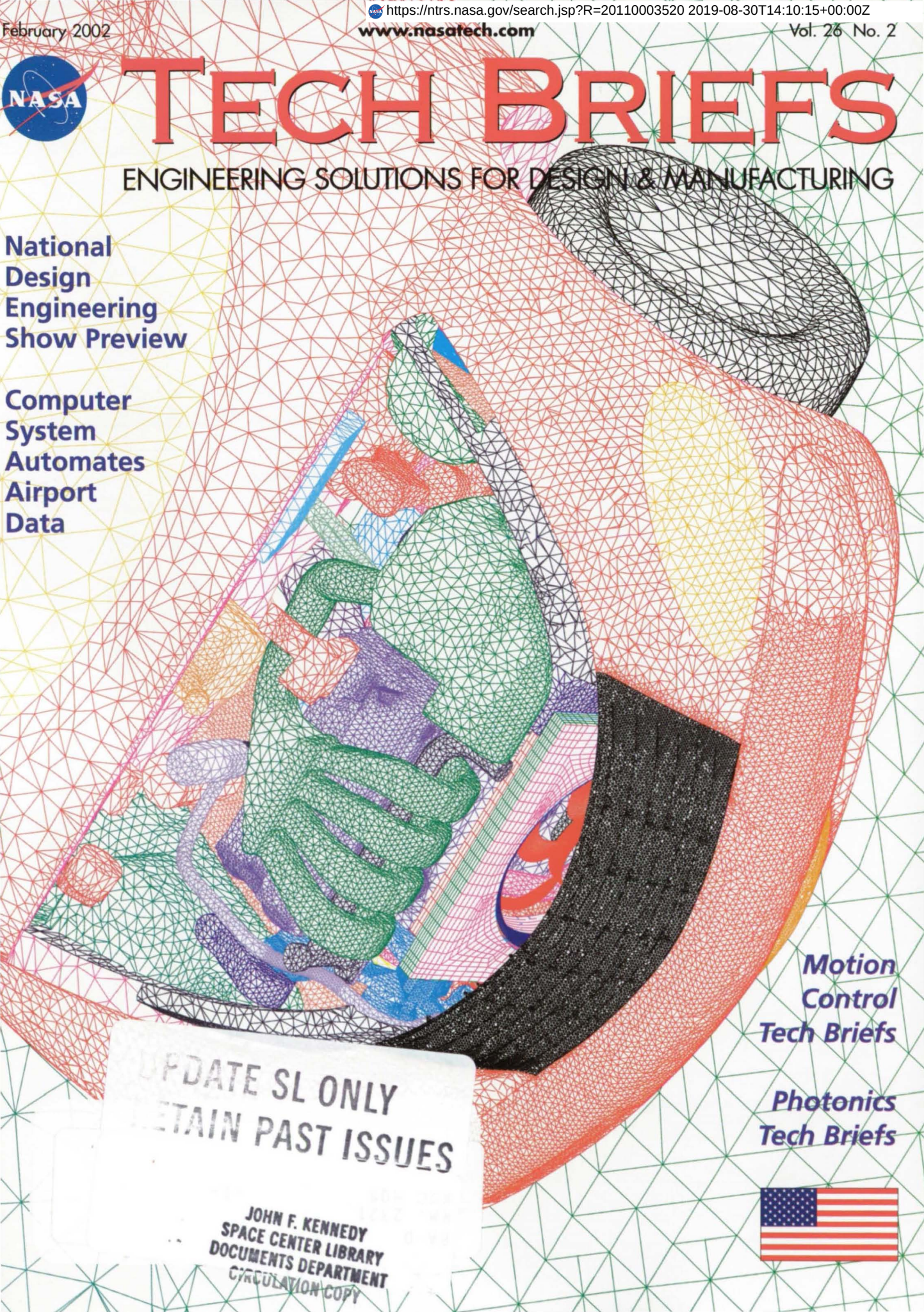
February 2002 www.nasatech.com Vol. 26 No. 2

TECH BRIEFS

ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING

National Design Engineering Show Preview

Computer System Automates Airport Data



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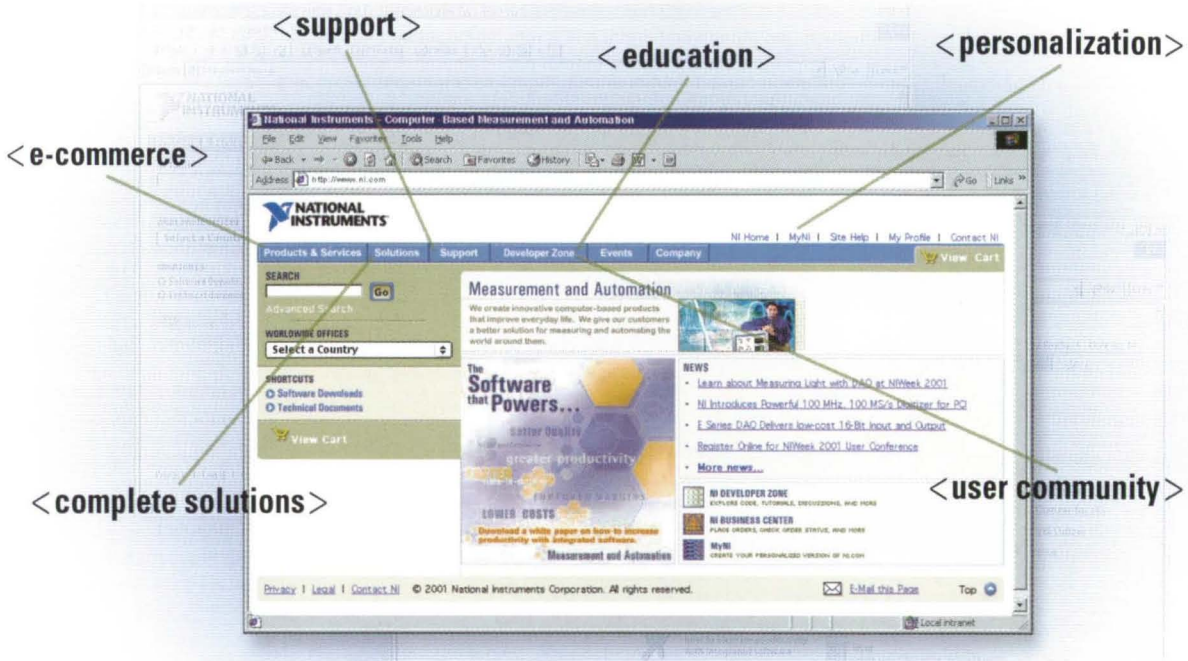

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CO_2 Laser Applications of the Month

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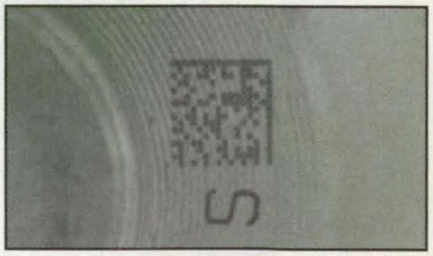
Marking Bar Codes on Cardboard & Wood with CO_2 Lasers

Marking text and graphics on cardboard and wood has always been an excellent application for sealed CO_2 lasers, but bar and Data Matrix™ codes have previously been considered unmarkable, as the resulting contrast was generally not high enough to be read without the use of a vision system. With Synrad's versatile laser marking software, WinMark Pro®, this is no longer the case. These codes can be made up of closely nested spots, which provide the needed contrast to make them readable with just a handheld scanner. The sample in the photo to the right was marked with a 25-watt CO_2 laser at a speed of 6" per second.

Bar and Data Matrix™ codes, marked on bare cardboard using WinMark Pro's Spot tool. The 2.3"x0.5" bar code was marked with a cycle time of 6 seconds, and the 0.4"sq. Data Matrix code in 1.5 seconds.

Laser Marking Data Matrix™ Codes on Steel

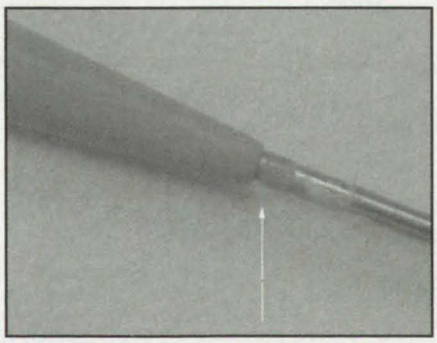
2D codes have gained popularity in the automotive and other industries, thanks to their ability to pack a large amount of information into a very small space. Synrad CO_2 lasers are ideal for marking these codes on a wide range of materials, including mild and stainless steels. Often considered the domain of Nd: YAG lasers, steel marking can be easily accomplished with a CO_2 laser - and, in some applications, as little as 50 watts is all that is required! CO_2 lasers can offer users a number of benefits over YAGs, including fewer safety requirements and higher contrast on some metals. Generally, for applications requiring less than 100 watts of power, CO_2 lasers are significantly less expensive than YAGs.



The Data Matrix™ Code (~0.2" sq.) on this torque converter was marked using WinMark Pro's Spot tool. The code was marked with 95 watts of power at a speed of 1" per second (7.4 second cycle time).

Laser Removal of Plastic Flashing

This medical device, made of MDPE (Medium Density Polyethylene), was rotated at 300 rpms, while the flashing was removed with 18 watts of laser power and 5psi air assist. The process results in a desirable smooth, rounded edge, with no loose plastic debris. HDPE, LDPE, and PTFE can also be cut with the same results. The metal rod was used to form the inside diameter of the part during production.



The flashing was removed from this plastic part with a Synrad 25-watt laser.

Discover more CO_2 laser applications! Sign up for our monthly online Applications Newsletter at ***www.synrad.com/signup1***

All applications on this page were processed at ***Synrad's Applications Laboratory****. Synrad, the world's leading manufacturer of sealed CO_2 lasers, offers free process evaluations to companies with qualified applications. Call 1-800-SYNRAD1 for more information.*

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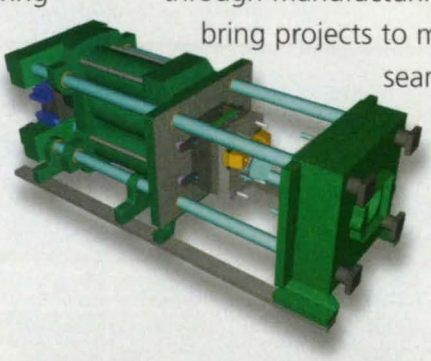

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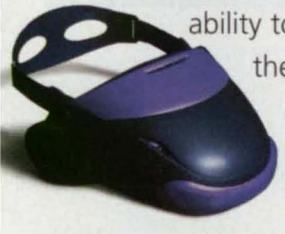

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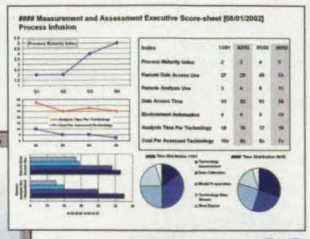
FEATURES

SOLUTIONS



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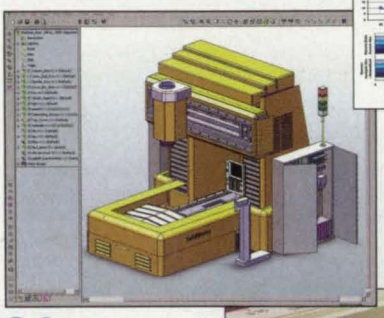

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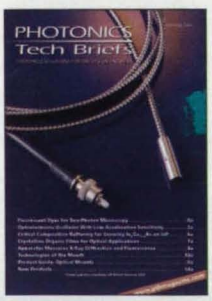

MEMS

ALGOR SIMULATES MEMS

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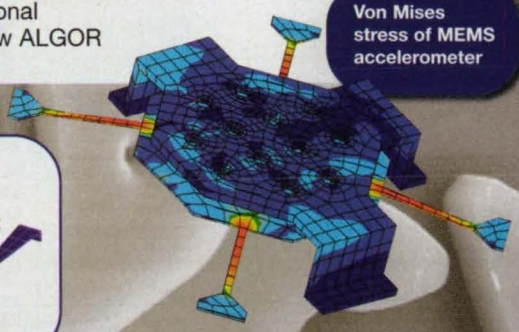

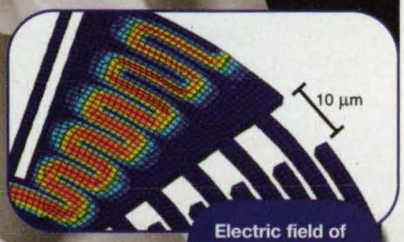

ALGOR's direct-selling and high-technology business model delivers the best FEA-based simulation value for MEMS simulation in the CAE industry. ALGOR's MEMS solution links electrostatic analysis to structural analysis tools with an easy-to-use graphical user interface that works within many popular CAD systems and includes a precision FEA model building tool.

WHAT ARE MEMS?

Micro Electro Mechanical Systems (MEMS) are micromachines the size of a grain of salt or the eye of a needle that integrate mechanical elements, sensors, actuators and electronics on a common silicon substrate. MEMS applications include optical switches within telecommunication and networking systems, accelerometers in automotive airbags, inkjets in desktop printers and sensors in medical testing equipment. The emerging MEMS industry promises to make the next generation of electronic products smarter and cheaper.

ALGOR'S MEMS SOLUTION INCLUDES:

- Multiphysics analysis software to simulate the real-world mechanical behavior for several physical factors acting simultaneously, such as:
  - Electrostatic analysis software that calculates forces due to surface charges
  - Mechanical Event Simulation for virtual replication of dynamic events with linear and nonlinear material models that predicts electromechanical effects driven by electrostatic forces
  - Structural analysis software that predicts electromechanical effects driven by electrostatic forces
  - Piezoelectric material models for Mechanical Event Simulation and static stress analysis
  - Composite material models for Mechanical Event Simulation and static stress analysis
  - Thermal analysis for considering the effects of heat transfer
  - Fluid flow analysis for considering the effects of fluid dynamics
- An easy-to-use graphical user interface that enables engineers to directly apply electrostatic forces to a structural model and provides right-click functionality for applying, modifying and removing loads, constraints and finite element properties
- Built-in precision FEA model building capabilities with geometric scaling and structured meshing capabilities
- InCAD technology for CAD/CAE interoperability within Autodesk Inventor, CADKEY, Mechanical Desktop, Pro/ENGINEER for Windows, Solid Edge and SolidWorks
- Unstructured brick and tetrahedral meshing
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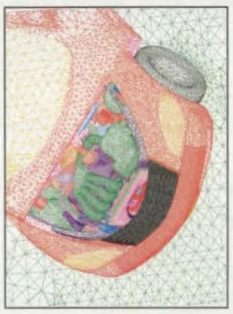
Photos courtesy of Sandia National Laboratories

Contents *continued*

PRODUCT OF THE MONTH

Broadax Systems, Inc. (BSI), City of Industry, CA, offers the FieldGo M5B10 portable workstation for rugged environments.

ON THE COVER



ANSYS, Inc.'s ICEM computational fluid dynamics (CFD) technology was used to develop this CATIA-based CFD model of Chrysler's PT Cruiser to study flow behavior in the engine compartment. The model consists of hexahedral, tetrahedral, and prism cells. The analysis was conducted with both Fluent and STAR-CD programs. ANSYS (Canonsburg, PA) is one of the exhibitors featured in our preview of the National Design Engineering Show, beginning on page 24.

(Image courtesy of DaimlerChrysler)

I am an engineer and I want to make a difference in my job and in this world. I work with formulas and models, vectors and forces, details and standards.

I think in terms of mathematical expressions—not programming languages—so I rely on tools that are intuitive, reliable and deliver exceptional performance.

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(650) 604-1754
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Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Jenny Baer-Riedhart
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Goddard Space Flight Center
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George Alcorn
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galcorn@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
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Johnson Space Center
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(281) 483-3809
commercialization@jsc.nasa.gov

Kennedy Space Center
Selected technological strengths: Fluids and Fluid Systems; Materials Evaluation; Process Engineering; Command, Control and Monitor Systems; Range Systems; Environmental Engineering and Management.
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(757) 864-6005
s.a.morello@larc.nasa.gov

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PRODUCT OF THE MONTH

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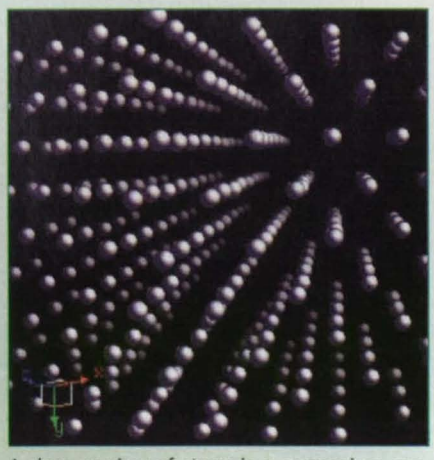
NASA Crystal-Growing Experiment May Benefit Electronics Industry

At NASA's Marshall Space Flight Center in Huntsville, AL, Frank Szofran and his colleagues are growing high-quality crystals by carefully cooling a molten germanium-silicon mixture inside a cylindrical container. The mixture forms into a single large and extraordinarily well-ordered crystal that has very few defects. The reason: remarkably, the crystals never touch the walls of the container in which they grow.

When the crystal-growing procedure was discovered in Skylab experiments in the 1970s, scientists had no idea how it happened. Since then, crystal growers have named the process "detached Bridgman growth."

Growing perfect crystals is important since they are used in a variety of devices on Earth, including microchips, video cameras, radiation detectors, digital watches, semiconductors, infrared sensors, and tiny solid-state lasers.

"In general, when people grow crystals for electronics applications, they would like them to be the highest quality possible — the lowest number of impurities, the lowest number of dislocations," said Szofran. "When crystal growth takes place in contact with the container wall, the container pushes on the crystal, and that causes the atoms to be nudged out of alignment. Such defects, as they're called, can cause the crystal not to perform as well," Szofran explained.



A close-up view of atoms in a germanium crystal. The goal of Szofran's experiment is to minimize the defects in the orderly arrangement of the atoms. (Image from WebElements.com)

The important aspect of the detached Bridgman growth procedure is that scientists have learned how to grow crystals using the method on Earth, rather than just in space — a clear advantage to industry.

Contact Frank Szofran of NASA Marshall at 256-544-7777 or frank.szofran@msfc.nasa.gov.

On the Road Again

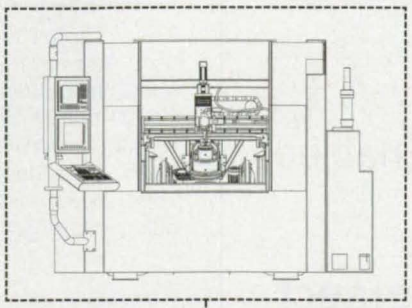
Technology derived from the space program affects our lives every day, from home smoke detectors and cordless power tools to implantable heart devices and protective clothing. You can get a closer look at the benefits of space technologies through NASA's "Benefits of Space on Tour."

A semitrailer owned and operated by NASA's Johnson Space Center in Houston will visit special events throughout the country next year from February through November. Schedule permitting, it also will stop at malls, universities, and schools.

"The Benefits of Space on Tour exhibit clearly depicts the many ways in which technologies derived from the U.S. space program impact everyone's daily life and identifies tremendous potential for even greater future benefits to the public from the ongoing exploration of space," said Charlene Gilbert, Johnson Space Center's director of technology transfer and commercialization.

The semitrailer is divided into two sections, each of which can hold 30 people. The first section is the Technology Hall of Fame, which features audio and video exhibits on a dozen space program spinoffs. After viewing the exhibits, visitors continue into a SurroundSound theater, where a 10-minute video on the past, present, and future of the space program is shown.

For information on the display's schedule of events and stops, contact David Haines of NASA Johnson at 281-244-1151 or david.d.haines1@jsc.nasa.gov .



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Thanks to all of our readers who voted in the 2001 NASA Tech Briefs *Readers' Choice Awards for Product of the Year. Your winners will be announced during National Manufacturing Week in Chicago next month, and will be posted on our Web site at* ***www.nasatech.com.***

I am looking for a formulation for a four-part epoxy system that is to be poured into a soft steel mold. The four components are an epon 828 resin and its hardener, an air release agent, and graphite filler to improve thermal conductance. It is very important that there are no air inclusions in the final molded product. Is anyone aware of any standard formulations that would fit this bill? So far I have been unsuccessful in removing all of the air bubbles from the resin. Thank you.

Jon Kingsbury
jsk1@cisunix.unh.edu

Does anyone know the procedures for certification of testing equipment in order to maintain ANSI, MIL, ASTM, NIST, and ISO standards? Are there any crossovers so that if one meets ISO and MIL standards, it also automatically meets ASTM standards, for example? What is the schedule for calibration of equipment? Does it need to be done by an independent, or can I utilize strict procedures and train someone to do this in house? We want to do it right, but the expense is somewhat unreal. Thanks for any information.

Joe M.
nuprosale@msn.com

*(**Editor's Note:** Joe, have you checked out the American National Standards Institute (ANSI) Web site at www.ansi.org? If you go there and click on "Standards Info," you'll find information on ISO, ANSI, and other standards, as well as how they relate to ANSI standards.)*

I'm looking for information on surface finishes and their corresponding effects on boundary layers. In particular, I have a pump with two 2" diameter rotating lobes used for compressing gasses. These are machined to high tolerance (0.0004 gap b/w lobes and side walls; 0.0002 b/w lobes). They also rotate at about 7000 rpm. I am interested in using surface finish to create a large boundary layer, which in turn would prevent or slow down gas leakage around the lobes. Any information would be appreciated.

Rocky Van Asten
rocky@engrworkshop.com

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William Berry, Deputy Director, Ames Research Center

William Berry is the deputy director of NASA's Ames Research Center in Moffet Field, CA. He is involved in the construction of a new 200-acre research park in Silicon Valley.

NASA Tech Briefs: What is the purpose of this research park?

William Berry: In 1994, part of Ames' center was adjacent to the Moffet Naval Air Station, which was shut down as part of the base realignment and enclosure process, and the land was transferred to NASA. About three years ago, we came up with a plan to leverage that land and turn it into Ames Research Center. That occurred simultaneously with realignment made from traditional aeronautics research that moved into information technology and other related fields around Silicon Valley — that's what led to a research park.

This research park will be open to the public and serve as an educational medium. We also expect the park to lead research and development and advance Ames' mission. The park will focus on astrobiology, life sciences, space sciences, nanotechnology, biotechnology, IT, and aeronautics.

NTB: What organizations are expected to take part?

Berry: We expect the University of California to be the anchor tenant. They are establishing a Silicon Valley Regional Campus here that will do research and education aligned with Ames' mission. Carnegie-Mellon University has opened Carnegie-Mellon West on our campus here. We're in the process of doing an environmental impact statement, which covers many of the aspects of what we're doing. Other partners are the Computer History Museum, the California Air and Space Center, and we're actively soliciting a proposal right now from a corporate sponsor to help provide the infrastructure, and be an enabler for the entire research park.

NTB: When do you expect the park to be completed?

Berry: Completion is going to be a 10- to 20-year project. The environmental impact statement decision will be given this summer. That statement will be an enabler for the construction of the research park, which is envisioned as 2.5 million square feet of construction.

NTB: What type of research do you expect to take place?

Berry: Ames Research Center is the most basic research center out of all of NASA's centers. I expect nanotechnology and biotechnology to bring much more to NASA than we envision now. I expect that we will be able to produce a new launch vehicle beyond the shuttle for human space flight and exploration. By applying new research to information technologies we can reduce the cost of these systems.

NTB: What will the benefits be for industry and the public?

Berry: The NASA Research Park will focus its NASA-sponsored research activities in the Info/Bio/Nano triangle. However, the first significant research is CMU's High Dependability Computing and Communications consortium. We would expect some commercial opportunities to flow from that. Companies like IBM, Sun Microsystems, Cisco Systems, and Oracle have signed on to work on a number of initiatives including air traffic control, Internet communication, space exploration, highway safety, and healthcare projects.

A full transcript of this interview appears online at ***www.nasatech.com/whoswho****. Mr. Berry can be reached at wberry@mail.arc.nasa.gov. For more information on the NASA Research Park, visit* ***http://researchpark.arc.nasa.gov****.*

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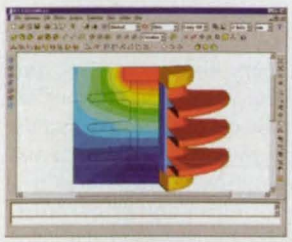

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Modular Fuel Injection System Simplifies Installation and Optimizes Performance

Bosch

Multi-port fuel injection is the standard method used to deliver fuel to the cylinders in automotive engines. Fuel injectors are refined devices that require individual electrical connections and exact positioning to operate correctly.

A new modular approach requires fuel injectors to be mounted on a common connection strip that in turn fastens directly to the engine. The valves are connected with locking collars designed to fit in the exact rotational position, aligning the fuel stream plane perfectly with a predetermined position to optimize the fuel mixture. Applications include power equipment, stationary internal combustion engines, rocket propulsion systems, and any chemical or fuel blending system.

Get the complete report on this technology at:
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Modified Manufacturing Process Yields Uniform Silica Spheres

Shell

Most silica pellets, or spheres, require high crushing strength and uniform sphere size, particle size, and pore volume distribution for catalyst supports and many petroleum, chemical, and process industry applications. Silica spheres are produced using the sol-gel method, which unfortunately does not leave the particles very uniform in size or porosity.

Researchers at Shell discovered that the key to narrow particle size distribution and controlled uniform size and porosity was the drying process. The researchers developed a patented multi-stage drying process using standard sol-gel chemistry and drying equipment. By carefully controlling the initial, partial drying stage, the end result is remarkably uniform alkaline or neutral silica spheres, ideal for use as catalytic carriers with active compounds in such processes as hydrometallization of heavy hydrocarbon oils.

Get the complete report on this technology at:
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SOI CMOS Improves Integrated Circuits

Honeywell

A silicon-on-insulator (SOI) technology provides almost total isolation of individual transistors by isolating each component in the circuit in its own "island" of insulating material. The technology produces reliable integrated circuits with long lives at high temperatures. Key to this circuit performance improvement is the use of a buried oxide layer which enables RF integrated circuit (RFIC) products to achieve better channel-to-channel isolation for RF switches and faster times for SRAMs and ASIC networks.

Honeywell is currently using SOI technology to produce mixed mode integrated circuits (MMIC) that integrate digital, analog, RF, and microwave circuitry on the same silicon die, providing up to 30% higher transistor packing density than standard processes.

Get the complete report on this technology at:
www.nasatech.com/techsearch/tow/honeywell.html
Email: nasatech@yet2.com
Phone: 617-557-3837

Using Hot Air to Improve Microwave Cooking

Enersyst

Though convenient, microwave cooking often results in a soggy end-product. Enersyst engineers, food scientists, and chefs have combined microwave technology with high-performance convection methods. The basic concept is to augment jets of hot air directed over the surface of foods with microwaves, improving surface temperature control and texture, and providing even browning for meats and crispy crusts for dough products. The technology can be used with any cookware material.

The first method "stirs" the microwaves and hot air streams and enables the intensity of the heat applied to the bottom of a pan to be changed by adjusting the elevation of a rack above a bottom air jet. A second variation includes a separate air-conditioning chamber that circulates temperature-controlled air into the microwave chamber to facilitate crisping and browning. A third method directs hot air down the sides of a specially designed food container, causing the container to heat evenly on all surfaces.

Get the complete report on this technology at:
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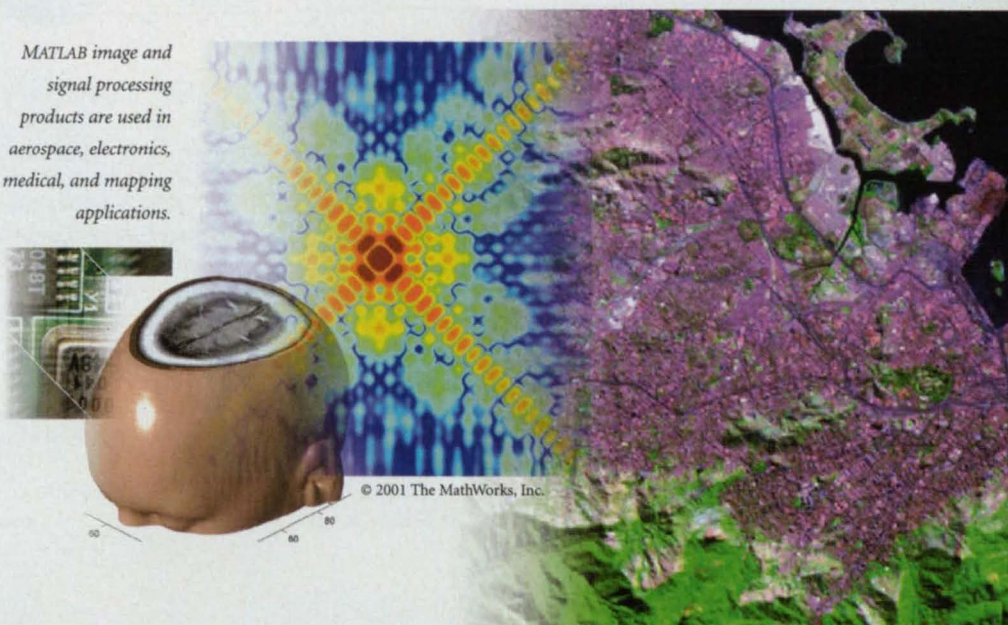

The MathWorks

Visit www.mathworks.com/nti or call 508-647-7040

Measurement System Helps NASA Assess Engineering and Software Needs

The Metrics System value-measurement software
MSC.Software Corp.
Santa Ana, CA
(714) 540-8900
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To improve NASA's engineering capabilities, former Administrator Daniel S. Goldin established the Intelligent Synthesis Environment (ISE) Program. Particularly, the ISE centers around developing and deploying advanced software systems, optimizing innovative approaches to mission development, and reducing cost and delivery time. Designed to work through a series of evaluations and methodologies, the ISE assesses technology, process, and cultural issues. One of the biggest challenges facing NASA was obtaining accurate measurements of progress — project managers, scientists, and engineers found it difficult to find the time to assess change and improvement in their activities. Requiring the evaluation of performance and technology investments, NASA utilized a metric system developed by MSC.Software Corp.

The Metrics System is a numbers-based measurement of the impact a specific software or process change brings to an organization, helping its adoption and successful implementation. Utilizing a balanced scorecard approach — including metrics indexing utilizing multiple methods such as surveys, metrics reporting, case studies, and automated metrics-gathering to provide information about the technology, processes, and culture — the Metrics System shows how a system performs within a given organization and how the organization has been affected by the system.

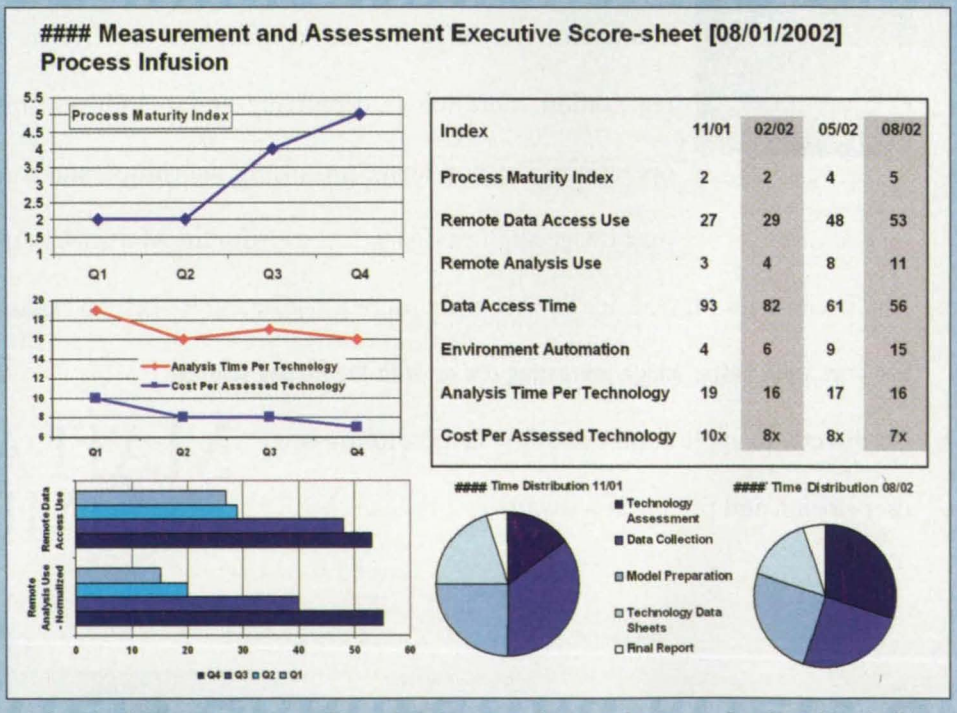
The Metrics System is not a measure of an individual's performance, but, rather, of the system's capabilities in a particular environment, taking into account design, analysis, IT, data management, collaboration-enabling applications, and critical capabilities of the software infrastructure that engineers rely on to make decisions and create new or enhanced products. The system is applicable to any software used in an engineering environment, such as CAD, PDM, and simulation.

Preliminary deployment of the Metrics System already has demonstrated that implementation of simulation software at Kennedy Space Center resulted in a decrease in simulation cycle time from six months to two weeks. There was also an increase in product quality and a reduction in risk.

Pat Simpkins, who was responsible for the initial implementation of the Metrics System at NASA, explained that the need for the metrics system came from program management who required selection criteria and benchmarks for determining where limited funds would be most wisely disseminated.

"The metrics efforts would enable the program and project managers to make intelligent and informed decisions on the best use of their resources. In any Federal budget year, there is a constant push-and-pull activity with respect to monetary and human resources. Those programs that are unsuccessful, provide no benefit, or are of a low priority, cannot continue," said Simpkins.

Simpkins said that the system allowed the ISE to complete and optimize capabilities of the Reusable Space Transportation Program and the Space Shuttle and ground processing applications. The ISE utilized a variety of capabilities of the Metrics System, "including customer satisfaction surveys, focus groups, and scenario evaluations," added Simpkins. With the aid of the Metrics System, "a 'map' of current and possible future processes was also established, allowing a better measurement and assessment of activities with the system. More importantly, each of the application areas became cognizant of the importance of being involved in the use of metrics for results."



Index	11/01	02/02	05/02	08/02
Process Maturity Index	2	2	4	5
Remote Data Access Use	27	29	48	53
Remote Analysis Use	3	4	8	11
Data Access Time	93	82	61	56
Environment Automation	4	6	9	15
Analysis Time Per Technology	19	16	17	16
Cost Per Assessed Technology	10x	8x	8x	7x

Though it is too early to evaluate results, Simpkins believes the global value of the evaluation program "has certain applicability across a myriad of IT programs and projects. Just the application of a 'balanced scorecard' in the IT arena by itself is a leap forward." He also believes that as the system matures, "the next tools and methods deliverable for the metrics activity can help other organizations within and outside NASA to develop a viable metrics program for their programs and projects."

With the Metrics System, NASA will discover how advanced software solutions are impacting its processes and design decisions. This communication is essential to successfully implement new technologies and processes, resulting in lower costs and faster time to market.

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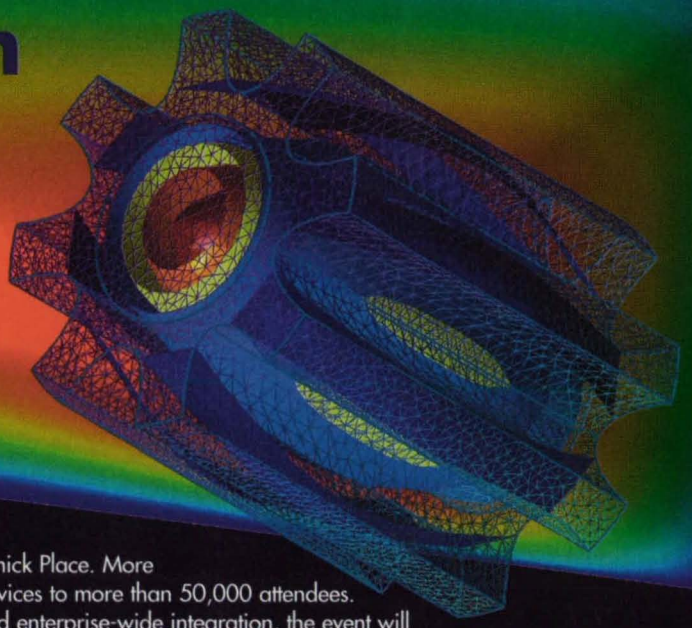
National Design Engineering Show Preview



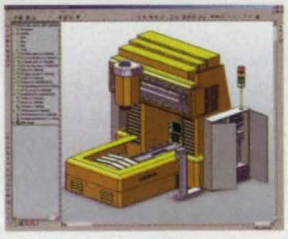
Presented by the National Association of Manufacturers, the 12th annual National Manufacturing Week (NMW) will be held from March 18-21 at Chicago's McCormick Place. More than 2,000 exhibitors will be displaying their new products and services to more than 50,000 attendees. From design engineering and plant management, to automation and enterprise-wide integration, the event will cover all aspects of manufacturing technologies.

The National Design Engineering Show (NDES) — one of NMW's four shows — addresses the needs of the $770 billion design engineering market. Nearly 1,000 exhibitors will display the latest tools, components, and materials that engineers use in mechanical and electromechanical design and product development.

Look for the following products that will be on display. For more information on the show, visit www.manufacturingweek.com/design.

Booth 6900

SolidWorks 2001Plus 3D CAD software is available from SolidWorks Corp., Concord, MA. Enhancements to the Windows-based product include new productivity tools such as physical dynamics, which calculates the actual contact and transference of motion from one component to another. Top Down configuration tools let users control sketch relations, equations, and feature end collisions, as well as view what-if design variations. Other enhancements include exploded drawing views, a split part feature, new assembly design tools, 2D to 3D design, and sheet metal capabilities. **For Free Info Circle No. 701 or Enter No. 701 at www.nasatech.com/rs**

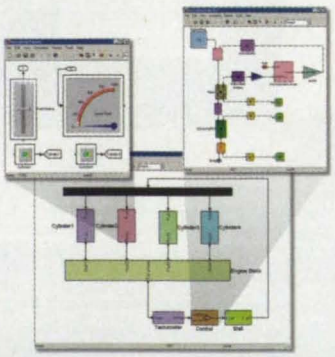


Booth 6900

Also highlighted in the SolidWorks booth will be the AI*Solutions line of simulation products and technology platforms from ANSYS, Canonsburg, PA. The product line includes AI*Workbench for creating custom engineering simulation solutions; AI*EMAX, a high-frequency electromagnetic analysis product for analyzing RF/microwave passive components and circuits; and AI*Environment, which combines ICEM CFD Engineering's pre- and post-processor technologies with ANSYS simulation to enable modeling and meshing for structural, thermal, and CFD projects. The company also will focus on its partnership with SAS LLC to develop a new NASTRAN product that will be distributed by ANSYS. **For Free Info Circle No. 728 or Enter No. 728 at www.nasatech.com/rs**

Booth 8216

The MathWorks, Natick, MA, will demonstrate SimMechanics, a modeling domain that extends Simulink® simulation software to provide an environment for modeling mechanical plants and controllers. It contains physical modeling blocks that represent components found in mechanical systems, and that satisfy well-known mechanical equations. **For Free Info Circle No. 722 or Enter No. 722 at www.nasatech.com/rs**



Booth 7422

Machine housings and enclosures are available from Rose+Bopla Enclosures, Frederick, MD. The Alubos extrusion product line features rounded corners and colored gaskets for those requiring a handheld enclosure. It is offered in seven profile sizes that can be cut to any length and capped with endplates. Mobile handheld machine control units interface between man and machine using housings made of PVC extrusion. End caps are injection-molded in glass-filled polyamide. Plastic side pieces are ridged for better handling and are adjustable to provide a wider or narrower front panel width. **For Free Info Circle No. 704 or Enter No. 704 at www.nasatech.com/rs**

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Prof. Francisco Valero-Cuevas
Neuromuscular Biomechanics Laboratory
Sibley School of Mechanical and Aerospace Engineering
Cornell University

"Because of their off-the-shelf solutions for miniature force and torque sensing, we were able to go from concept to working prototype in months instead of years."

Patrick Jensen, Ph.D., Assistant Professor of Ophthalmology
Johns Hopkins University

"The force/torque systems from ATI are ideal in our study of human grip force coordination and production. They are as close to a turn-key system that we have found."

Professor Jay L. Alberts, Ph.D.
Dept. of Health and Performance Sciences
Georgia Institute of Technology

ATI manufactures a variety of extremely robust six-axis Force/Torque (F/T) sensors that provide low-noise, high-resolution signals with output speeds of up to 10kHz and factors of safety up to 27 times measurement range. Since 1983, ATI has provided thousands of customers with F/T's ranging from the smallest six-axis sensor in the world (17 mm diameter) to sensors measuring thousands of pounds. The F/T can provide data via voltage outputs, RS-232 serial or interface with either ISA, PCI, PCMCIA or cPCI buses. ATI is developing interfaces to Firewire, VXI, USB, DeviceNet and Ethernet. The F/T can also interface with analog data acquisition systems (seven channels required).

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Booth 6911

MSC.Software Corp., Santa Ana, CA, will demonstrate MSC.visualNastran 4D 2002, a Windows-based tool that sets 3D assemblies into motion, animates the resulting stresses, and lets engineers measure the performance of moving components. It supports virtually every CAD system and analyzes rigid body dynamics, motion-related stress analysis, and structural responses such as vibrations, deflection, and buckling. Photorealistic rendering and animation are included, as well as steady-state heat transfer, topology optimization, redundant constraint relief, and gear, belt, and joint friction constraints. **For Free Info Circle No. 721 or Enter No. 721 at www.nasatech.com/rs**

Booth 7511

VX Corp., Palm Bay, FL, will launch version 6 of VX Overdrive CAD/CAM software, which features an upgraded Web publishing tool, new PDM and collaborative product development tools, and an enhanced user interface. Other new features include improved wire frame tools, and extended control of solids, surfacing, and assembly. New tooling and milling functions such as mold design wizards and five-axis milling also are added. **For Free Info Circle No. 724 or Enter No. 724 at www.nasatech.com/rs**

Booth 5142

National Instruments, Austin, TX, will display the FieldPoint 2000 family of network modules that lets engineers create standalone measurement and control solutions. The company's LabVIEW graphical programming language can be embedded on compact industrial measurement I/O nodes to build real-time distributed monitoring and control systems. Each intelligent node acts as an independent component in a networked system and still communicates with a host Windows computer. FieldPoint consists of a variety of modular analog and discrete I/O, and several network interfaces for distributed I/O across Ethernet, serial, Foundation Fieldbus, and wireless networks. The modules combine I/O and signal conditioning with direct connectivity to sensors such as voltage, current, RTD, thermocouple, relays, and pulse generation. **For Free Info Circle No. 707 or Enter No. 707 at www.nasatech.com/rs**

Booth 7757

Pittman, Harleysville, PA, will exhibit the LO-COG® 22-mm brush-commutated DC motor that features a length of 1.900". The motor uses a skewed five-slot armature design and bonded neodymium iron boron magnets. Standard cartridge brush assemblies are designed to prolong brush life. Options include ball bearings, gearheads, and encoders. **For Free Info Circle No. 715 or Enter No. 715 at www.nasatech.com/rs**

Booth 4904

Dolch Computer Systems, Fremont, CA, offers rugged portable PCs in sizes from lightweight notebook styles to large-screen, multi-slot workstations. All units feature bulletproof construction with metal cases, environmental seals, and shock mounting. Expansion slots accept basic systems and custom applications with industry-standard add-in cards in ISA, PCI, or PC/104 form factors. Flat-panel TFT color monitors and intelligent displays are available in a variety of screen sizes and resolutions. **For Free Info Circle No. 725 or Enter No. 725 at www.nasatech.com/rs**

Booth 7345

Hybrid linear actuators in size 17 from Haydon Switch & Instrument, Waterbury, CT, are available with a 0.9° step angle, which is designed for higher resolution and a full step linear movement of 1.5 microns. The actuators are available in captive, non-captive, external linear, and linear rotary designs. The actuators have resolutions ranging from 0.00006" to 0.002" per step, with operational thrust capabilities of up to 50 pounds. They are for use in applications such as X-Y tables, medical equipment, semiconductor handling, telecommunication equipment, and valve control. **For Free Info Circle No. 706 or Enter No. 706 at www.nasatech.com/rs**

Booth 7919

CADKEY Corp., Marlborough, MA, will introduce CADKEY GraphX™ mechanical drawing software for drafters, mechanical design engineers, and manufacturing engineers. Built on an all-new Version 20 architecture, the product lets users create accurate drawings from scratch, or generate drawings from solid, surface, and polygon models imported from other systems, including ACIS® and Parasolid®. Industry-standard data translators are included. The software uses intelligent dimensioning on native or imported drawings to prohibit the creation of dimensions that do not match geometry or are not properly constructed. **For Free Info Circle No. 711 or Enter No. 711 at www.nasatech.com/rs**

Booth 6501

Autodesk, San Rafael, CA, will highlight Autodesk Inventor 3D mechanical design software that enables engineers to move from 2D to 3D. The latest release features more than 200 new enhancements, including enhanced drawing annotation, Adaptive Technology, and integration with the Autodesk Streamline™ service. The software also features a design support system with context-sensitive tutorials, and design capabilities for large assemblies, machines, sheet metal, and sketching. **For Free Info Circle No. 729 or Enter No. 729 at www.nasatech.com/rs**

Booth 8916

Devcon, Danvers, MA, will display a line of methacrylate adhesives for hard-to-bond plastics, composites, and dissimilar substrates. They require little or no surface preparation and cure at room temperature to bonds that are resistant to weathering, humidity, and temperature variations. Epoxy adhesives are formulated to bond rigid substrates such as glass, metals, ceramics, plastics, concrete, and wood. **For Free Info Circle No. 708 or Enter No. 708 at www.nasatech.com/rs**

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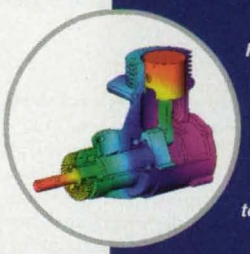

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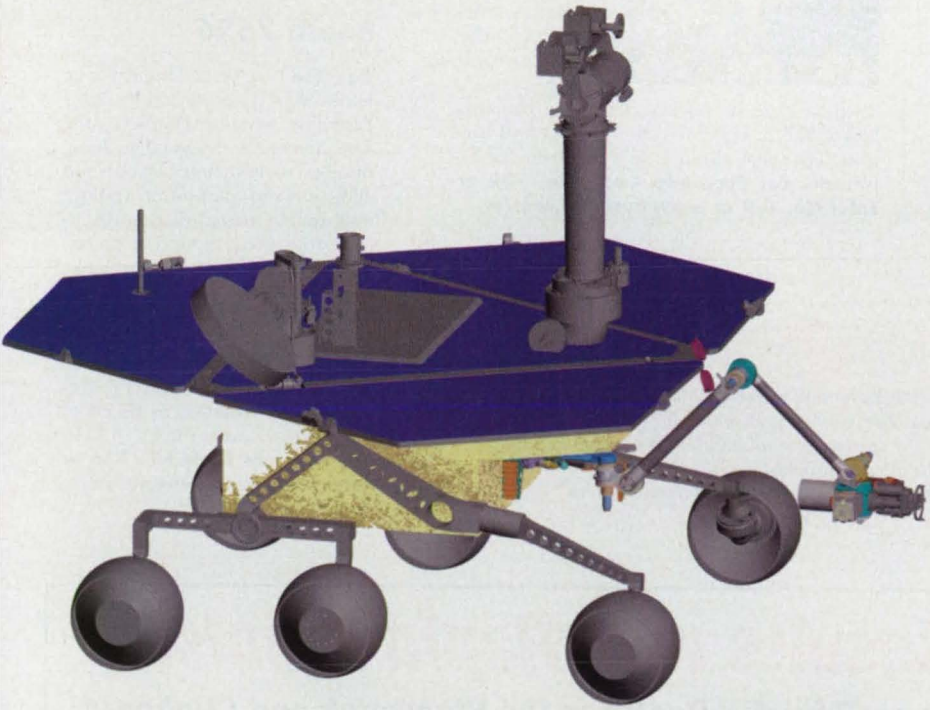

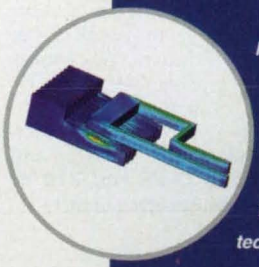

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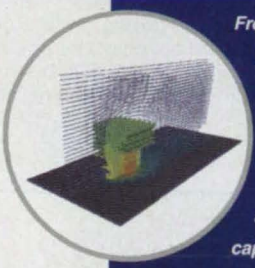
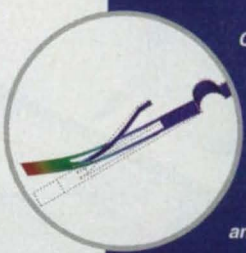
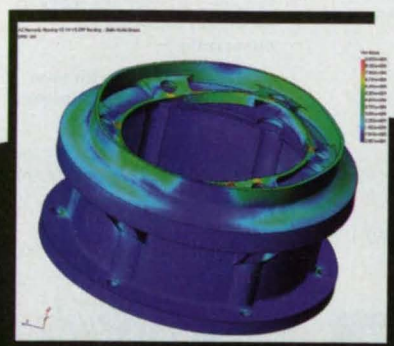


From designing the wing of an airplane to an exhaust valve, COSMOS/ offers a wide array of fluid flow and heat transfer capabilities.

In order for Alliance Spacesystems Inc. to design the robotic arm for the front of the Mars Exploration Rover, they needed an optimal combination of strength and light weight. With COSMOS/, they were able to reduce the weight 15-20% while still meeting NASA/JPL's exacting standards.



COSMOS/ gives engineers an integrated tool to simulate plastics, rubbers, other nonlinear materials and much much more!



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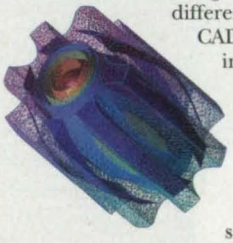
Booth 8217

FEMLAB® v2.2 multiphysics analysis software from COMSOL, Burlington, MA, features a new Electromagnetics Module and Chemical Engineering Module. The new version also features higher-order elements and extended multiphysics with model interaction between geometrical domains of different space dimensions. CAD import functionality includes 3D CAD import in the IGES format. A new feature is the weak form, which lets users compute fluxes, reaction forces in structural mechanics, and surface changes and currents. **For Free Info Circle No. 710 or Enter No. 710 at www.nasatech.com/rs**



Booth 6942

THK America, Schaumburg, IL, offers the Caged Ball™, Caged Roller™, and Caged Technology Ball Screw™ linear motion products.

The Caged Technology isolates each of the load-carrying recirculating elements in the linear motion guides in an individual cage or pocket. The cage prevents ball-to-ball or roller-to-roller contact and friction. The cage also acts as a reservoir for lubricants. **For Free Info Circle No. 709 or Enter No. 709 at www.nasatech.com/rs**

Booth 7526

Type TDO™ self-clinching cable-tie hooks will be introduced by PEM® Fastening Systems, Danboro, PA. The hooks are designed to hang bundled wires in an enclosure and allow users to temporarily remove and return tie-bundled wires to and from their mounting points. With the cable-tie hooks in place, tie-bundled wires can be slipped off. They install permanently without screws, use no adhesives, and promote EMI/RFI shielding. The hooks are available in several sizes and can be installed in sheets as thin as 0.040" or as thick as 0.125". **For Free Info Circle No. 716 or Enter No. 716 at www.nasatech.com/rs**

Booth 6716

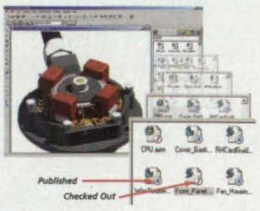
ManufacturingQuote, Smyrna, GA, will display MfgJobs.com, a Web-based recruiting and placement network for manufacturing professionals. The service automates recruiting and career discovery processes, and serves as a job center for contract, permanent, and consulting jobs in many manufacturing disciplines. The Web site offers career tools, privacy options, and other features. **For Free Info Circle No. 712 or Enter No. 712 at www.nasatech.com/rs**

Booth 7326

Intelligent Motion Systems, Marlborough, CT, offers the Mdrive34 NEMA size 34 high-torque motor and driver that incorporates a motor with on-board electronics. It is suited for robotics, medical instruments, assembly, semiconductor manufacturing, packaging, and inspection applications. The system uses a 1.8° motor combined with a microstepping drive, and accepts up to 14 resolution settings from 1/2 to 256 microsteps per step. Parameters can be changed via an SPI port. Operating voltage is +24 to +75 VDC. The motor is available in multiple configurations including single stack, optical encoder, linear actuator, and rear knob. **For Free Info Circle No. 717 or Enter No. 717 at www.nasatech.com/rs**

Booth 7505

EDS/PLM Solutions, Cypress, CA, will exhibit Solid Edge Insight that merges design data management capabilities with the Solid Edge Version 11 mechanical CAD software. Insight is a fully integrated solution that is transparent to Solid Edge users. Insight vaulting combines design documents and CAD files with attribute data in a common, secure index storage system that supports file locking, search, and role-based access. It features distributed data management, assembly link management, bill of materials management, and CAD property synchronization. **For Free Info Circle No. 718 or Enter No. 718 at www.nasatech.com/rs**



Booth 217

The Temposonics® R Series AQB quadrature interface position sensor from MTS Systems Corp., Sensors Div., Cary, NC, features programmable fixed pulse frequency and resolution. The AQB interface sensor generates an absolute position output either upon power-up or after receiving an input signal from the controller interface. Resolution varies from 50 to 12,500 counts/inch and pulse frequency ranges from 8 kHz to 1 MHz. The interface is available in rod style and profile style application housings. **For Free Info Circle No. 719 or Enter No. 719 at www.nasatech.com/rs**

Booth 7937

Optical Gaging Products, Rochester, NY, will display the SmartScope® Quest 250 benchtop multisensor video measurement system with TeleStar optics. The system provides video measurements with the convenience of a zoom lens. It integrates data from video, touch probe, and laser sensors to characterize a part. The touch probe acquires data from areas not accessible by the optics, and supports a variety of standard probe heads and styli. The TeleStar lens has collimated profile illumination that matches the aperture of the optics over its entire 10x range. **For Free Info Circle No. 720 or Enter No. 720 at www.nasatech.com/rs**

Booth 7911

An upgrade to FiberSIM 3.4 software will be available from VISTAGY, Waltham, MA. FiberSIM enables engineers working with CAD systems to create products made of lightweight composite materials. The software incorporates XML tools for sharing specialized design information about composite parts with other applications. It also provides enhanced documentation features, and editing, customizing, and display capabilities for manipulating geometric and non-geometric design data. **For Free Info Circle No. 723 or Enter No. 723 at www.nasatech.com/rs**

Booth 9255

Ceradyne, Costa Mesa, CA, will display rolling element products, including rollers and balls for bearing applications and cam rollers. The rollers have machined crowned profiles to minimize stresses in the ceramic and metallic components. The use of silicon nitride allows cylindrical roller bearings to run at higher speeds with less friction. Cam rollers operate at contact stresses of 1.0 to 2.4 GPa. **For Free Info Circle No. 713 or Enter No. 713 at www.nasatech.com/rs**

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Ground-Traffic Information-Management System for an Airport

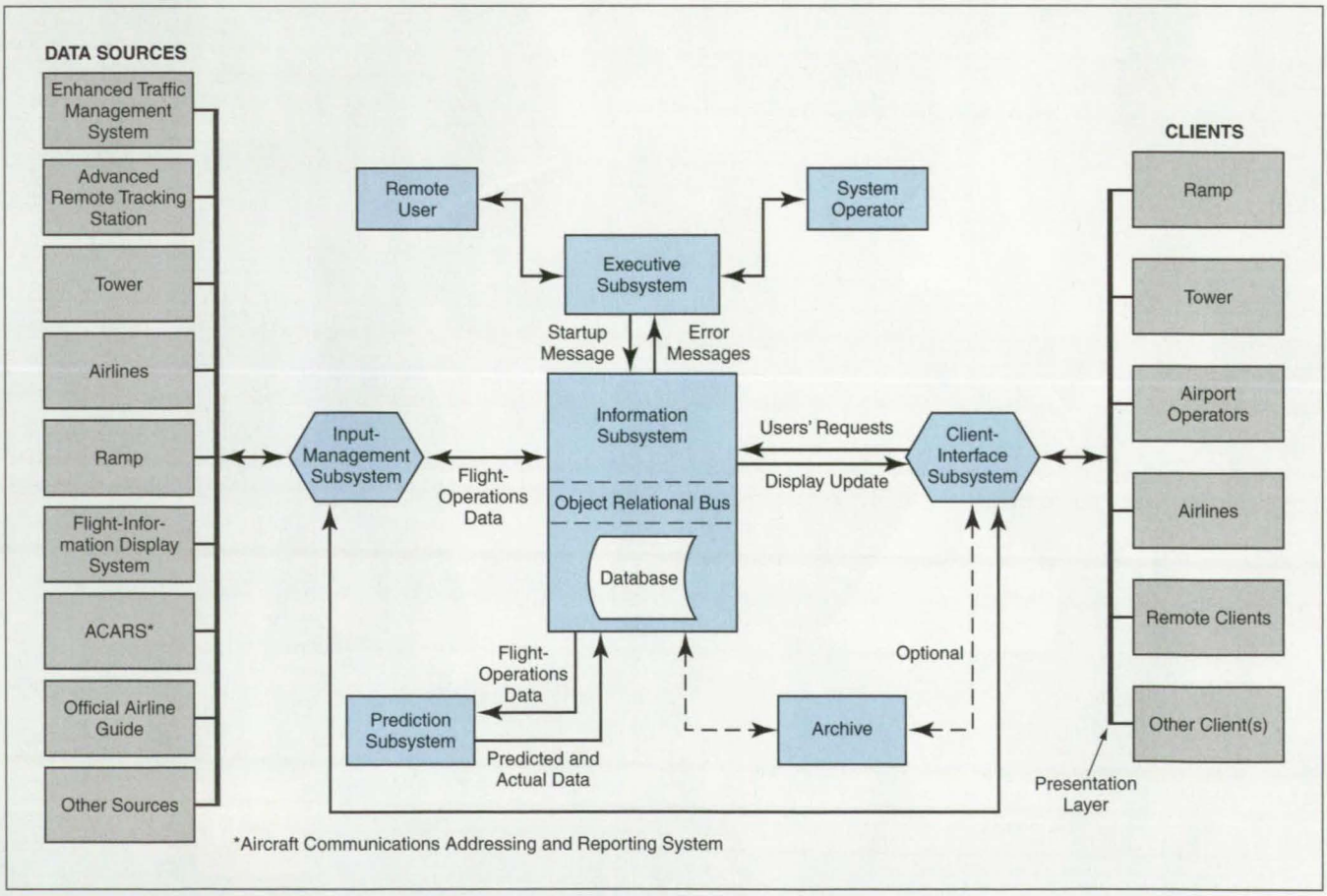
Real-time operational data are shared among diverse users to help minimize delays.

Ames Research Center, Moffett Field, California

A computer-based system, and a method built around the use of the system, have been developed to automate the acquisition, integration, and management of data that have been generated at different rates by multiple, heterogeneous, incompatible sources. The system [hereafter denoted the "TMS" (for "traffic-management system")] in its original form is intended for use in improving the management of ground traffic at a large, busy airport in order to reduce delays. The TMS could also be adapted to scheduling the movements of multiple vehicles in other settings — for example, vessels in harbors, trucks or railroad cars in shipping yards, and railroad cars in switching yards. Still other uses for the TMS could include managing containers at a shipping dock, managing stock on a factory floor or in a warehouse, and training of a variety of airline, airport, and government personnel in the management of airport ground traffic.

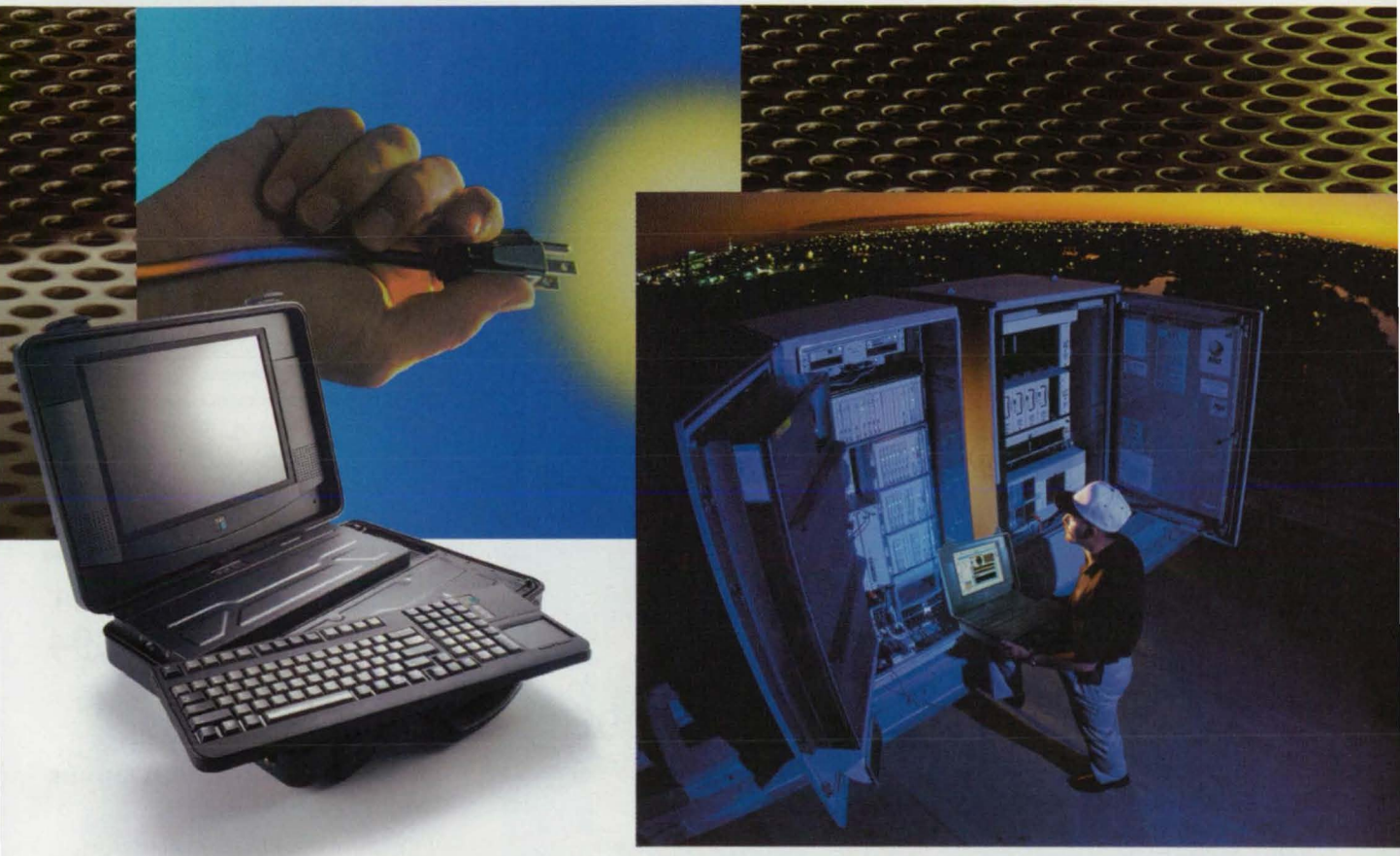
The basic TMS concept admits of variations. In a preferred representative version, the TMS is a client/server computer system that shares real-time aircraft-operations data among the Federal Aviation Administration (FAA), airlines, airport managers, and ramp controllers. The TMS (see figure) includes executive, information, input-management, prediction, and client-interface subsystems that are interconnected to participate in the interchange of real-time aircraft-operations data among the aforementioned groups. In addition to raising the level of coordination among these groups, the TMS generates its value-added data products for their use. These data products include estimated times of arrival of airplanes at gates and estimated airplane-departure times. The TMS uses expert-system software to fuse data in order to establish and update reference data values for every aircraft surface operation.

The executive subsystem is responsible for controlling the other subsystems, starting and shutting down processes at scheduled times, monitoring system components for error and warning conditions, notifying system-support personnel of detected system errors, and, when possible, recovering from system failures. Additional duties of the executive subsystem include fa-



The **TMS Is a Client/Server System** that helps various user groups to increase the level of coordination of airport operations and thereby reduce ground-traffic delays.

You can pull the plug...



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cilitating diagnoses of faults in subsystems, providing remote access for monitoring and control, maintaining system statistics, and managing user accounts. The executive subsystem can issue commands to reset various hardware components of the TMS.

The input-management subsystem is a collection of computer programs that handle the data coming in from various sources via network or serial links. In turn, the input-management subsystem feeds the data to the information subsystem.

The prediction subsystem is responsible for integrating all the input data in order to monitor the progress of arriving and departing flights, and to predict key events, including pushbacks (departures from gates), takeoffs, touchdowns, and arrivals at gates. The integrated monitoring information and predicted values are fed back to the information subsystem for display by the client-interface subsystem.

The client-interface subsystem is a collection of computer programs. In a preferred version of the TMS, the client-interface system distributes flight, TMS-status, and schedule data from the information subsystem to various clients, including the aforementioned sources of data and user groups and possibly other clients at remote locations. It also provides a graphical user interface for continuously displaying flight data on a bit-mapped display, and for executing various commands to change the data or the method of display.

This work was done by Brian J. Glass, Liljana Spirkovska, William J. McDermott, Ronald J. Reisman, James Gibson, and David L. Iverson of **Ames Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components & Systems category.*

This invention has been patented by NASA (U.S. Patent No. 6,161,097). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14268.

Mixed-Signal Driver ASIC for IEEE 1394 and I^2C Buses

Radiation-hardened ASICs enable communication among three different buses.

NASA's Jet Propulsion Laboratory, Pasadena, California

The IEEE 1394 and I^2C Mixed-Signal Driver is one of two application-specific integrated circuits (ASICs) designed to function together as an interface among the following three digital-signal buses:

- A peripheral component interface (PCI) bus;
- A high-speed serial data bus that conforms to Institute of Electrical and Electronics Engineers (IEEE) standard 1394, also known as the FireWire standard; and
- An I^2C (inter integrated circuit) bus, which was developed in the early 1980s by Philips Semiconductors for connecting a central processing unit to peripheral integrated-circuit chips in a television receiver.

Among other things that have been emphasized in the development effort are radiation hardness and compactness as required for intended use aboard spacecraft. As result of engineering compromises necessary for radiation hardness, the performance of this set of

ASICs is expected to lag somewhat behind that of comparable circuitry previously developed for terrestrial use. Nevertheless, because the capability for communication among the three buses is not afforded by any plug-in circuit cards now commercially available, there could be a terrestrial market for these ASICs for applications in which the tri-bus communication is required.

In the original spacecraft application, the two ASICs would enable communication among multiple computers, scientific instruments, and spacecraft engineering systems via the three buses. The first ASIC, which could be characterized as a digital input/output (DIO) ASIC, would provide a digital interface (a link layer) among the three buses. The second ASIC, denoted the IEEE 1394 and I^2C Mixed-Signal Input/Output Driver ASIC ("MSIO ASIC" for short) is the focus of this article. The MSIO ASIC would serve as the physical layer in the overall data-communication architecture.

The MSIO ASIC would implement an analog interface to the IEEE 1394 and I^2C bus cables. The MSIO ASIC would be connected, either directly or through an isolation transformer, to the DIO ASIC. The MSIO ASIC would receive digital commands and data from the DIO ASIC and pass these data and commands out through the IEEE 1394 and I^2C cables. The MSIO would contain a commercial controller core, custom analog bus cable-driver circuits, two I^2C-bus cable-driver cores, and custom glue-logic circuitry. The MSIO ASIC would be a radiation-hardened, galvanically isolated, three-port implementation of the physical-layer functions described in the IEEE 1394a D2.0 draft specification. The MSIO ASIC would also contain two radiation-hardened, galvanically isolated sets of I^2C drivers and receivers, independent of the 1394 interface and of each other.

This work was done by Huy Long, Peter Jones, Savio Chau, and Eric Holmberg of Caltech and Ross McTaggert of Digital MediaCom for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components & Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Intellectual Property group
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

Refer to NPO-30121, volume and number of this NASA Tech Briefs *issue, and the page number.*

Unity-Power-Factor Interfaces for Data-Processing Equipment

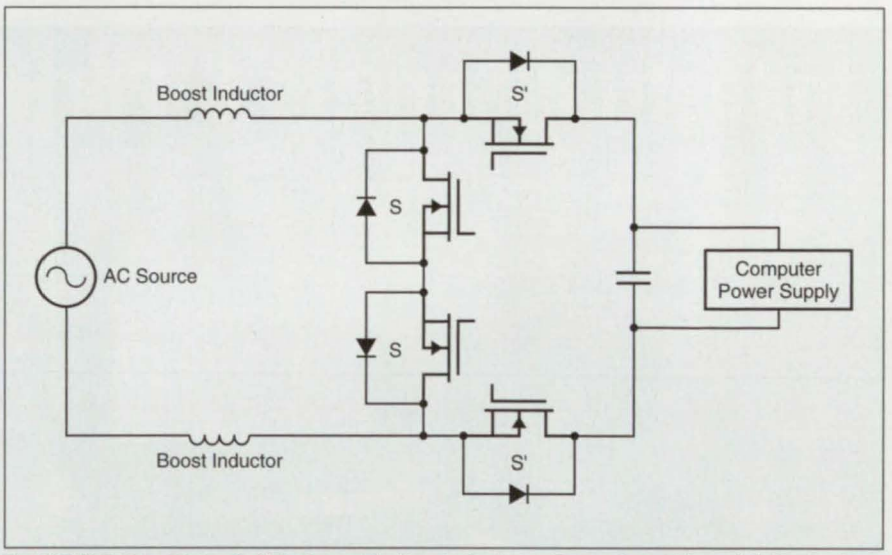
These could be manufactured as plug-in units.

John F. Kennedy Space Center, Florida

Circuits for conditioning AC power supplied to computers are under development. A power conditioner of this type would be an interface between a conventional AC power line and a computer power supply (that is, an AC-to-DC converter) that contains one or more rectifier(s) and inductor(s). Typically, such a power converter is characterized by a power factor <1, and, because it presents a nonlinear load to the power line, it injects currents at harmonics of the power-line frequency back into the power line. These harmonic currents can cause interference with the operations of other electronic equipment as well as overheating of power-line transformers.

The main purpose served by the power conditioner is to prevent injection of the harmonics into the power line and to bring the power factor up to 1. It would not be necessary to modify either the computer power supply or the AC-power-distribution system. Instead, the power conditioner could be manufactured as a plug-in unit that could simply be inserted between an AC outlet and the computer AC-power plug. Hence, it would be easy to retrofit a previously constructed system with power conditioners.

The effects of power factors <1 and power-line harmonics on power-distribution systems and data-processing equipment are well known. Prior to the present development, efforts to suppress these effects had included the development of unity-power-factor (UPF) rectifiers that include active current-shaping circuits to make the power-line currents drawn by the rectifiers sinusoidal. However, such rectifiers have not become popular in commercial data-processing equipment.



The **MOSFETs S and S′ Are Switched** on and off periodically to effect pulse-width modulation to shape the source current to a purely sinusoidal waveform when presented with a nonlinear load like a computer power supply.

The present developmental power conditioners can be characterized as boost AC-to-AC converters. Like the UPF rectifiers, these power converters utilize current shaping. In particular, they utilize pulse-width modulation as a versatile means of shaping currents to control the flow of power. The modulation in such a power converter is controlled by a combination of an inner average-current loop and an outer

voltage-control loop. Together, these control loops maintain a regulated output voltage while forcing the input current to be sinusoidal.

The figure is a simplified schematic diagram of such a power conditioner for a single-phase power line. When the metal oxide semiconductor field-effect transistors (MOSFETs) labeled S are turned on, the magnitude of source current through the boost inductors increases. When the MOSFETs labeled S′ are turned on, the magnitude of the current through the boost inductors decreases. Hence, by suitably modulating the switching of S and S′, the source current can be controlled to be sinusoidal.

This work was done by David Lofftus of GSE Technology Applications and Giri Venkataramanan of Montana State University for **Kennedy Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components & Systems category.*
KSC-12147

Program Injects Random Faults for Testing Computers

NASA's Jet Propulsion Laboratory, Pasadena, California

JIFI (Jet Propulsion Laboratory's Implementation of a Fault Injector) is a computer program for studying the ability of a computer to tolerate, detect, and/or recover from faults (that is, bit errors). JIFI affords the capability to inject faults into user-specified central-processing-unit (CPU) registers and memory regions with uniform random distributions in location and time. This capability makes it possible to study the fault sensitivity of either a computer regarded as a complete system or of a specified component of hardware or application software. JIFI operates at the application level and is easy to use. In contrast, prior fault-injection software operates at a lower level and is more difficult to use. JIFI includes fault-injection, profiling, output-verifying, and classifying subprograms that constitute parts of an easy-to-use software interface for performing fault-injection experiments and analyzing the resulting data. JIFI generates a fault-injection-result output file for each run. Data from massive fault-injection campaigns can be collected and processed automatically.

This program was written by Anil Agrawal, Garen Khanoyan, John Beahan, Leslie Callum, Raphael Some, and Won Kim of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30162.

February 2002

PHOTONICS Tech Briefs

PHOTONICS SOLUTIONS FOR THE DESIGN ENGINEER

Cover photo courtesy of Point Source LLD.

www.ptbmagazine.com

Fluorescent Dyes for Two-Photon Microscopy

Suitability for specific applications would depend on optical, chemical, and biological properties.

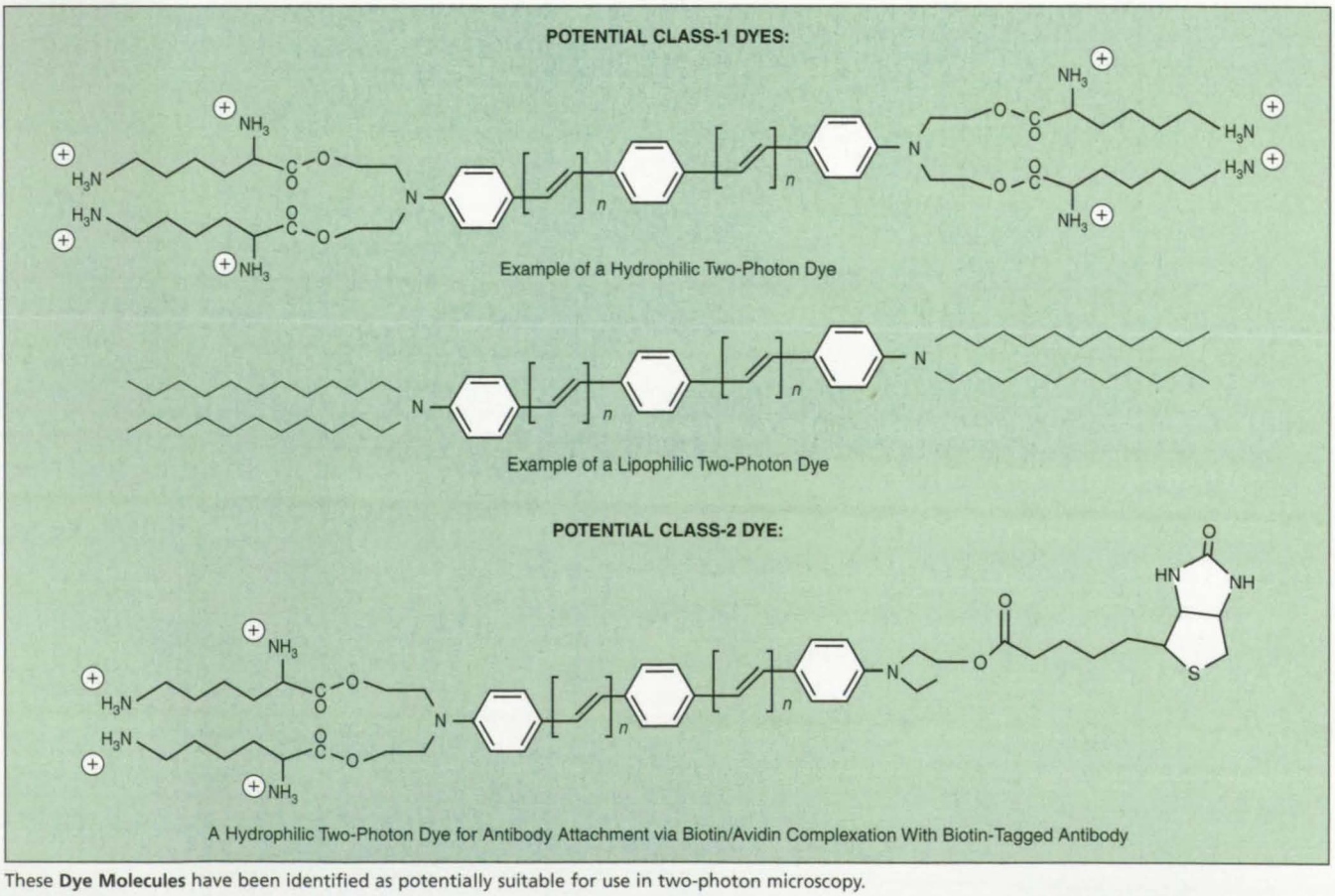
NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed program of research would be oriented toward the development of fluorescent dyes for use in two-photon microscopy. Two-photon microscopy and its predecessor, one-photon microscopy, are variants of fluorescence microscopy, which has become a major technology for biological and physical sciences. The basic idea in fluorescence microscopy is to use fluorescent compounds as markers for various physical and biological processes so that by observation of fluorescence under microscopes, one can locate those processes with high resolution in space and time. Because the fluorescence emitted by a compound can be isolated by its characteristic excitation and emission wavelengths, the compound can be traced with high signal-to-noise ratio, even in a "messy" environment. In two-photon microscopy, excitation of a fluorescent dye involves the concurrent absorption of two photons of approximately twice the wavelength of the peak of the single-photon-absorption spectrum.

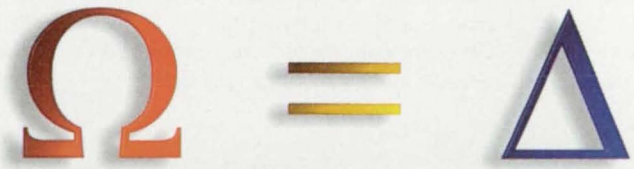
During the past few years, two-photon microscopy has evolved to the incipient development of a commercial two-photon microscope. Heretofore, two-photon microscopy has been performed with dyes optimized for one-photon microscopy; these dyes are unlikely to satisfy the requirements for future relatively inexpensive two-photon microscopes, which are expected to feature simplified optics and power-efficient, ultrafast lasers combined in such a way as to afford only about 1/25 of the sensitivity of previously constructed prototype two-photon microscopes.

The dyes to be developed in the proposed research would be optimized for two-photon microscopy. Preliminary research has revealed that at least three classes of dyes will be needed:

1. Vital dyes could be used to label cells and follow them over time. These could include hydrophilic dyes that would be trapped in cytoplasm or hydrophobic dyes that would be carried in organelles or in cell membranes. Vital dyes must be optimized for minimal toxicity and slow bleaching.
2. Hydrophilic marker dyes would be formulated for covalent linking of antibodies for use in immunocytochemical labeling of tissues. These dyes could be based partly on vital dyes. However, because these marker dyes would be used on fixed tissue, toxicity would not be of concern as in the case of vital dyes. Marker dyes must be very hydrophilic to minimize the "background" staining that would otherwise occur because the dye would interact with, and stick to, the tissue. Marker dyes must be optimized for brightness; bleaching is of less concern.
3. Phototoxic agents would be used to sensitize cells or tissues for selective killing by laser light. A tumor or pathogen would be targeted, either by direct interaction with a dye or by formation of a targeting complex that could include, for example, antibodies to a tumor antigen. The dye-labeled tissue would be irradiated with light that the dye would absorb; photoactivated damage or toxic byproducts of dye bleaching would then kill the targeted cells. These dyes are required to be nontoxic until and unless illuminated.



These **Dye Molecules** have been identified as potentially suitable for use in two-photon microscopy.



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The initial plan for the proposed research is straightforward, given that a few dyes (see figure) are already known to have properties that make them candidates for use in two-photon microscopy. These properties include absorption maxima in approximately the correct wavelength range and absorption cross sections about 50 times those of conventional dyes. The plan calls for the following coordinated efforts:

1. Synthesize dyes that (a) have two-photon-absorption wavelengths tuned for specific applications; (b) exhibit hydrophilicity suitable for control of biodistribution and, possibly, toxicity; and (c) are functionalized to provide for routine attachment to antibodies, caging complexes, and other biologically relevant compounds.
2. Determine lipo/hydrophilicity of each dye.
3. Measure two-photon cross sections at wavelengths from 780 to 1,000 nm, determine one- and two-photon-fluorescence quantum efficiencies, and characterize bleaching rates and byproducts.
4. Test each dye in a biological setting to determine toxicity with and without illumination and to determine performance under a microscope.

This work was done by Scott E. Fraser, Seth R. Marder, and Joseph W. Perry of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-20150, volume and number of this NASA Tech Briefs *issue, and the page number.*

Optoelectronic Oscillator With Low Acceleration Sensitivity

A fiber-optic delay line is arranged to minimize changes in optical-path length.

NASA's Jet Propulsion Laboratory, Pasadena, California

An optoelectronic oscillator with a nominal operating frequency of 11.763 GHz has been designed and constructed to demonstrate a technique for reducing the sensitivity of the operating frequency to acceleration. Optoelectronic oscillators in general exhibit low sensitivity to acceleration in addition to other attractive characteristics (high spectral purity, low phase noise, capability for generating multigigahertz frequencies, and both electrical and optical input and output capabilities). The practical significance of the present development is that the reduction of acceleration sensitivities to exceptionally low levels would render optoelectronic oscillators even more attractive as signal sources for use on diverse moving platforms, including automobiles, ships, aircraft, and spacecraft.

The optoelectronic oscillator (see Figure 1) includes a distributed-feedback laser and a feedback loop that comprises a semiconductor Mach-Zehnder electro-optical modulator, a delay line that consists of a coiled 2-km-long optical fiber, a photodetector, a microwave amplifier, and a band-pass filter. The oscillator also includes an electronic controller that drives the laser, regulates the temperature of the laser, biases the modulator and the photodetector, and supplies power to the microwave amplifier. All of the oscillator components except the fiber-optic delay line are packaged in a module that amounts to a prototype of "turn-key" (fully operational) optoelectronic oscillator units.

Of course, firm mounting of the components within the module is an essential part of the design for reducing sensitivity to acceleration. Most of the remaining sensitivity to acceleration is attributable to acceleration-induced changes in the length of the optical path along the fiber-optic delay line; therefore, the problem of desensitization to acceleration becomes one of minimizing these changes.

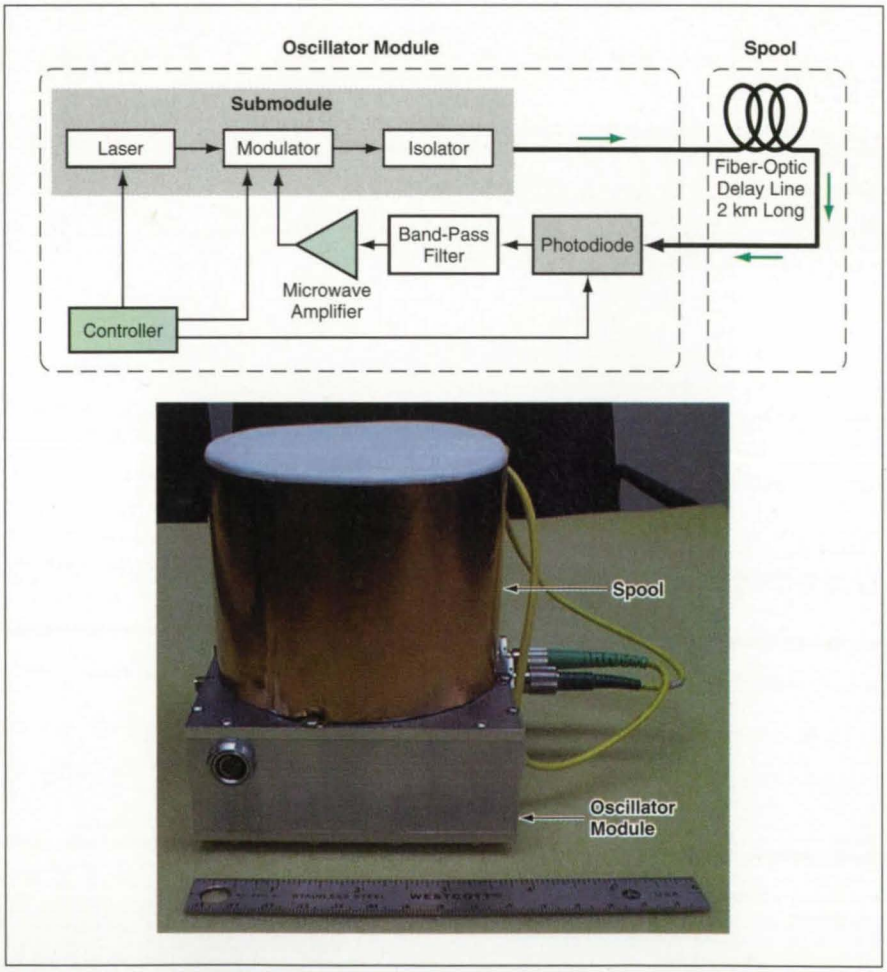

Figure 1. The **Optoelectronic Oscillator** (shown here before modification to reduce sensitivity to acceleration) comprises an oscillator module and a fiber-optic delay line.

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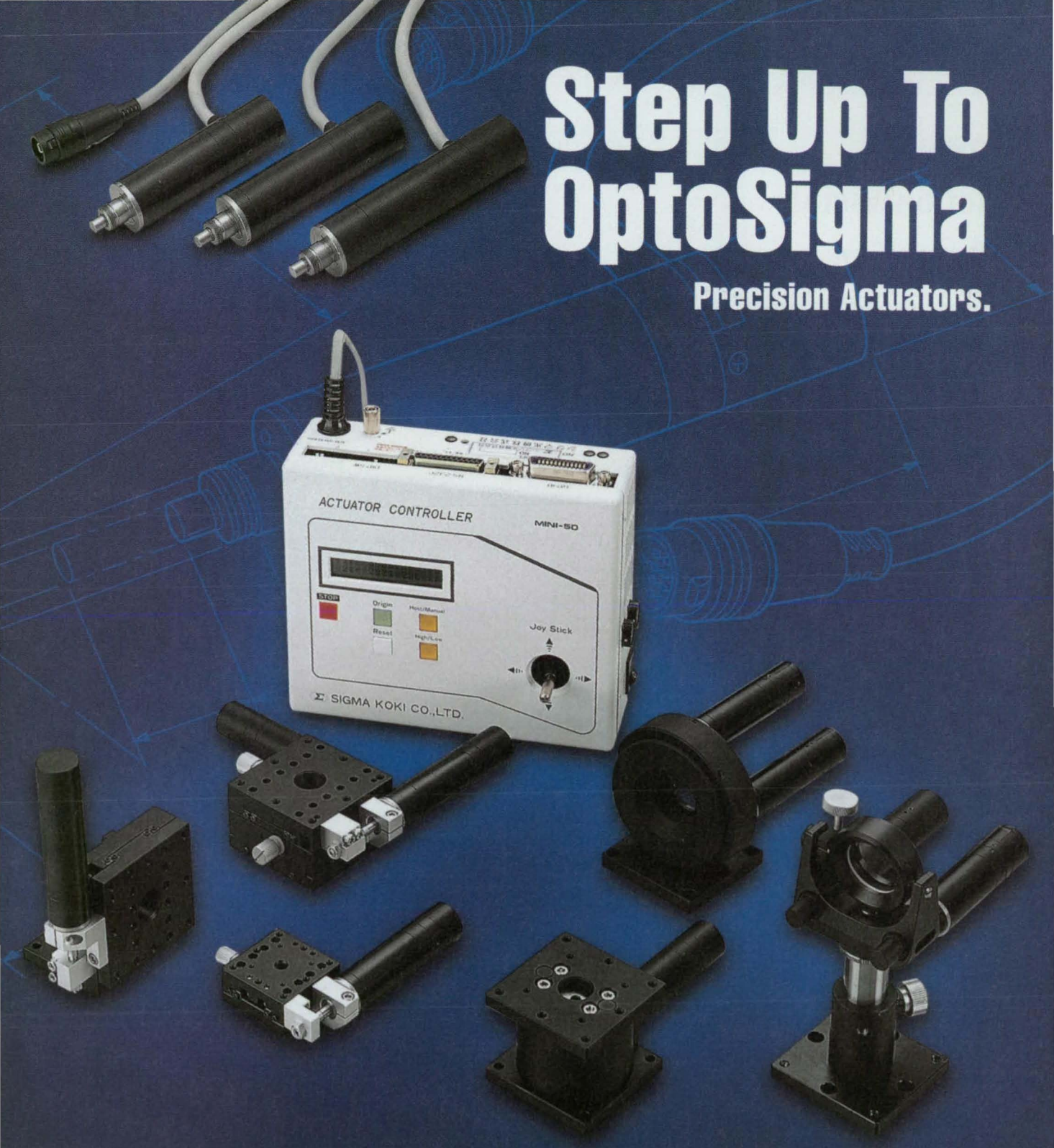

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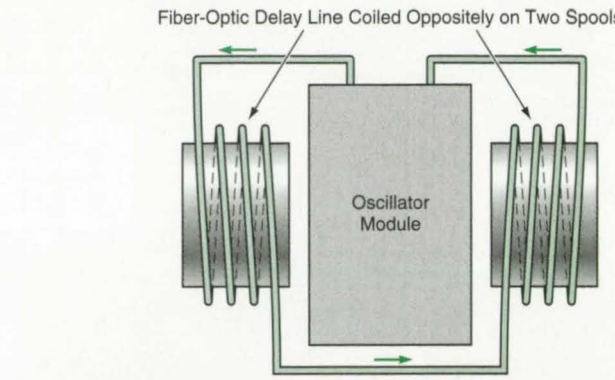
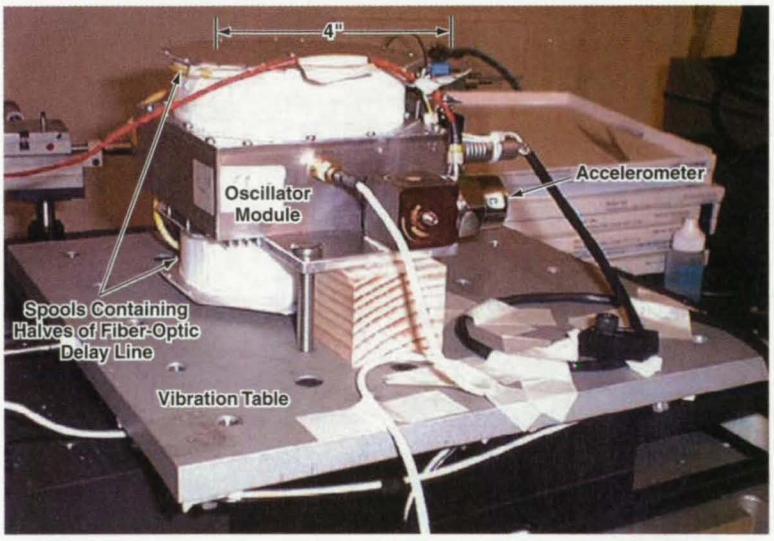


SCHEMATIC DIAGRAM SHOWING ARRANGEMENT OF COILS



PHOTOGRAPH OF OSCILLATOR MOUNTED FOR TESTING ON VIBRATION TABLE

Figure 2. The **Fiber-Optic Delay Line Has Been Split** into two coils of opposite chirality. In combination with other features of design and construction, this split greatly reduces the sensitivity of the oscillator to acceleration along the coil axis.

Experiments and calculations have shown that if the fiber-optic delay line is coiled tightly on a spool, then the sensitivity to acceleration perpendicular to the spool axis is less than 1/20 of the sensitivity to acceleration along the spool axis. Hence, the problem is reduced further in that it should be possible to eliminate most of the sensitivity to acceleration by concentrating on minimizing the response to acceleration along the spool axis.

The solution of the problem is to split the fiber-optic delay line into two coils that are of opposite chirality but are otherwise identical and that are mounted on opposite faces of the oscillator module (see Figure 2). In principle, when acceleration along the spool axis lengthens the optical path in one coil by a given amount, it should shorten the optical path in the other coil by the same amount, so that the net change in optical-path length should be zero. Measurements have shown that the sensitivity is reduced to about 1/40 of that obtained of a single-coil version of the delay line. The total sensitivity to acceleration along all three axes was found to be less than 1.5×10^{-10} g^{-1} ($\approx 1.5 \times 10^{-11}$ s^2/m), where g (≈ 9.8 m/s^2) is the gravitational acceleration at the surface of the Earth.

This work was done by Shouhua Huang, Meirong Tu, and X. Steve Yao of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components & Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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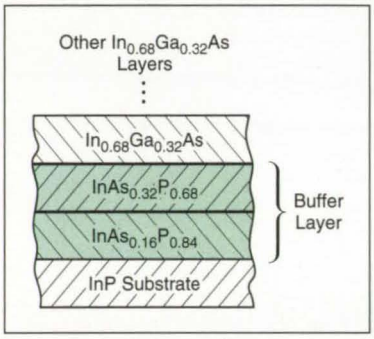
Critical Composition Buffering for Growing $In_xGa_{1-x}As$ on InP

Improved buffer structure for lattice-mismatched InGaAs devices.

John H. Glenn Research Center, Cleveland, Ohio

A method of growing lattice-mismatched $In_xGa_{1-x}As$ epitaxial layers on InP substrates using intermediate buffer layers of $InAs_yP_{1-y}$ has been invented to improve the performance of $In_xGa_{1-x}As$ thermophotovoltaic devices. The use of buffer layers is required to minimize the density of threading dislocations generated because of the lattice mismatch between low-bandgap $In_xGa_{1-x}As$ and InP. These defects degrade the electrical performance of the InGaAs device by acting as recombination centers for minority carriers.

The traditional approach to buffer layer design strives to accommodate the stress developed by the lattice mismatch through generation of misfit dislocations that are confined to the substrate/epilayer interface, while minimizing the generation of threading dislocations that propagate through the epitaxial layer(s). Often, many buffer layers, strained layer superlattices (SLS) or thermal cycle growth techniques are used to increase the interaction of threading dislocations, thereby reducing the overall dislocation density. The method described here utilizes a different phenomenon first observed in InGaAs grown on GaAs, whereby the strain of lattice mismatch is accommodated by dislocation formation in the substrate and underlying buffer layers rather than the top device epilayers. The success of this method depends on the selection of the composition of each buffer layer according to several criteria, most notably the following:



Only Two $InAs_yP_{1-y}$ Buffer Layers with carefully chosen values of *y* are needed to bridge the lattice mismatch between the InP substrate and the first $In_{0.68}Ga_{0.32}As$ layer.

- The yield strength of each buffer layer must exceed that of the adjacent lower layer (including that of the substrate) so that dislocations are preferentially generated in the softer, lower layers.
- The buffer layers must be in compression, relative to the substrate.
- The compositions of the buffer layers must be chosen to make the lattice mismatch between any two adjacent layers less than a critical value, below which few or no dislocations propagate up through the layers to the overlying $In_xGa_{1-x}As$. This translates to making the compositions of the adjacent buffer layers differ by less than a corresponding critical amount.

It has been seen that the yield strength of an alloy of two materials varies with composition, with the maximum occurring at a 50/50 mixture. For example, it has been suggested that the yield strength of InGaAs has a maximum at a composition of $In_{0.5}Ga_{0.5}As$ (at elevated temperatures characteristic of epitaxial growth). The use of InGaAs buffer layers for the growth of low bandgap (i.e., 0.6 eV) $In_{0.68}Ga_{0.32}As$ on InP may begin with a $In_{0.53}Ga_{0.47}As$ buffer layer lattice-matched to the InP substrate and be comprised of InGaAs layers with increasing In content and lower yield strength. Thus, the buffer layer structure begins with a strong material followed by successively weaker materials. Stress tends to be relieved by dislocation formation in the weaker overlying layers. The opposite is true for buffer layers composed of $InAs_yP_{1-y}$. The buffer structure begins with InP and proceeds with successively higher yield strength material, thereby encouraging the formation of threading dislocations in the underlying materials. Cross-sectional TEM (transmission electron microscopy) analysis has verified this behavior of $InAs_yP_{1-y}$ buffer layers on InP. This technique allows buffer layers to be produced with fewer and thinner layers, providing cost and operational benefits.

The figure depicts the buffer-layer structure of a typical $In_xGa_{1-x}As$ thermophotovoltaic device fabricated by the present method. In this case, *x* is chosen to be 0.68 to obtain a bandgap of 0.6 eV. Only two $InAs_yP_{1-y}$ buffer layers are needed: For the first buffer layer, *y* is chosen to be 0.16 to obtain a lattice mismatch of 0.58 percent with the substrate. For the second buffer layer, *y* is chosen to be 0.32 to obtain both a lattice mismatch of 0.51 percent with the first buffer layer and a lattice match with the first $In_xGa_{1-x}As$ layer.

This work was done by David Wilt of **Glenn Research Center** *and Richard W. Hoffman of Essential Research, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16776.

Crystalline Organic Films for Optical Applications

Nonlinear optics can be implemented as smaller, less power-hungry devices.

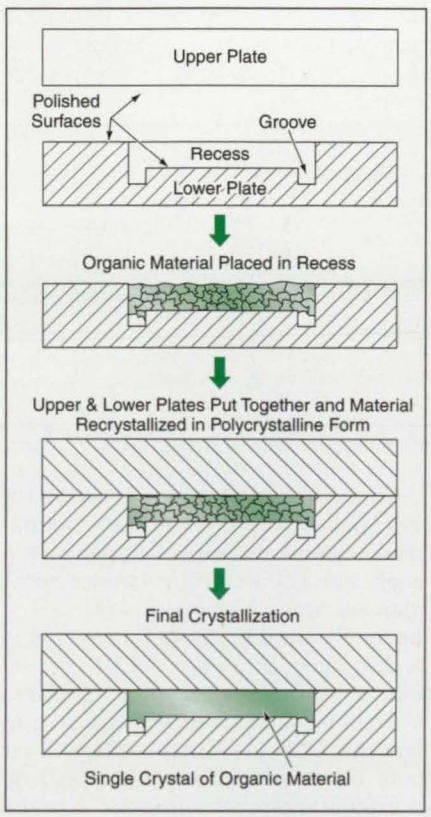
Marshall Space Flight Center, Alabama

Cells that contain thin, single-crystal films of photoresponsive organic materials [e.g., meta-nitroaniline (m-NA)] have been invented for use as nonlinear optics and especially as second-harmonic generators. In comparison with crystals of potassium dihydrogen phosphate (KDP) that have been used previously in such applications, the crystals of this invention are smaller and are capable of producing second harmonics of input light at lower input power levels.

A cell according to the invention (see figure) includes an upper and a lower plate made of fused quartz or other transparent material. A recess to hold the organic material is formed in the lower plate. The recess includes a groove around its periphery. The upper surface of the lower plate, the broad upward-facing surface of the recess, and the lower surface of the upper plate are optically polished to (1) eliminate defects that would otherwise act as seeds for undesired nucleation of multiple crystals in the final crystallization process described below and (2) enable the upper and lower plates to fit closely together. The dimensions of the final organic crystal are determined by the dimensions of the recess — typically a diameter of the order of 10 mm and a thickness between 0.5 and 500 μm.

The quantity of the organic material placed in the recess is chosen so that the material fills all of the recess except for the groove; this is because the groove serves to absorb any excess of the organic material during melting and/or thermal expansion, to prevent the material from flowing between (and thereby forcing apart) the faying surfaces of the upper and lower plates. Once the organic material is placed in the recess, the upper and lower plates are put together. The resulting cell containing the organic material is heated to melt the organic material, then cooled to freeze the organic material in a polycrystalline form with an even distribution of grains.

The cell is then placed on a controlled-temperature, heated stage under a polarizing microscope, so that the organic material can be heated and cooled for the final crystallization and the microscope can be used to observe the crystallization process. The temperature of the stage is first increased to the melting point, taking care that except for a single seed crystal of desired orientation, all the organic material is melted. The seed crystal can be singled out under the microscope, and while all other crystals melt, it can be kept solid by exposing it to a microjet of cool air. The temperature of the stage is then slowly decreased, causing the organic material to freeze as a single crystal that grows outward from the seed crystal.



A **Single Crystal of an Organic Material** with a nonlinear optical response is formed by controlled solidification in a recess between two optically polished transparent plates.

This work was done by Alexander Leyderman of the University of Puerto Rico for **Marshall Space Flight Center**. *For further information, please contact the innovator at alex@feynman.upr.clu.edu.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (256) 544-0021. Refer to MFS-31450.

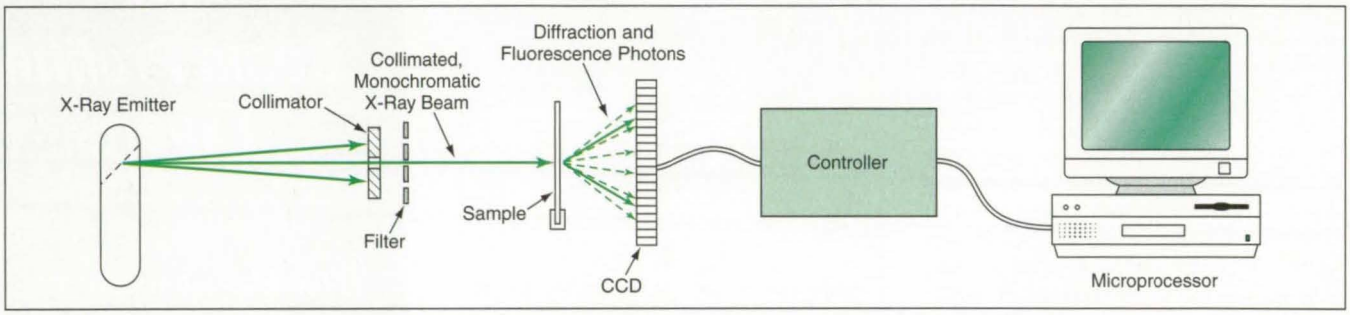
Apparatus Measures X-Ray Diffraction and Fluorescence

A single apparatus performs functions for which two apparatuses were previously needed.

Ames Research Center, Moffett Field, California

The figure depicts an apparatus for measuring x-ray diffraction (XRD) and/or x-ray fluorescence (XRF) in a specimen of material. The specimen could be, for example, a standard XRD powder sample of a mineral, the elemental composition of which one seeks to identify. It is common practice to characterize samples in terms of both XRD and XRF, but heretofore, it has been necessary to use separate XRD and XRF apparatuses.

The apparatus (see figure) includes a standard x-ray emitter — preferably one that generates x-rays at a number of photon energies. The x-ray beam from the source passes through a collimator, and the collimated beam passes through a band-pass filter, so that the sample is irradiated by a collimated, monochromatic beam.



The **Readout From the CCD** in this apparatus yields information on the XRD pattern and XRF spectrum of the sample.

The irradiated specimen emits mainly two kinds of x-rays: (1) primary (diffraction) photons at the incident photon energy; and (2) secondary (fluorescence) photons, which have lower energies. The photons emitted by the specimen travel to a charge-coupled device (CCD) containing a two-dimensional array of pixels, wherein the photons are detected. In general, the CCD pixel outputs depend on both the fluorescence spectrum and on the diffraction pattern projected onto the array of pixels. By suitable choice of the mode of operation, one can extract diffraction or fluorescence information from the CCD pixel outputs, as explained below.

Typical CCDs rival traditional Si(Li) detectors with regard to energy resolution and sensitivity in the energy range of 0.2 to 10 keV. Taking advantage of this characteristic, the CCD can be operated in a photon-counting mode; the CCD can be interrogated at such short intervals that in each successive interrogation, the output comprises indications of the energies of individual photons incident on single pixels. Taking further advantage of this characteristic, the CCD pixel outputs can be processed to select only those signals in a desired photon-energy range. The CCD pixel outputs are processed partly in a controller and partly in a microprocessor connected to a display unit.

The apparatus can be operated in any of several distinct modes, of which four are described below:

1. The sample is irradiated with a monochromatic beam and only the diffraction pattern is of interest. To discriminate against fluorescence photons, the CCD and the processing circuitry are operated so that only photons at the primary beam energy are counted in computing the diffraction pattern.
2. The sample is irradiated with a monochromatic beam and both diffraction and fluorescence are of interest. The CCD and processing circuitry are operated to measure both the primary and lower-energy photons. The diffraction pattern is extracted from the signals at the primary photon energy, while the fluorescence spectrum is extracted from the signals at lower photon energies.
3. The irradiating beam is monochromatic and only the fluorescence spectrum is of interest. In this mode, CCD outputs at the primary beam energy are rejected, and only the lower-energy signals are used in calculating the fluorescence spectrum.
4. The x-ray beam is polychromatic (a band-pass filter is not used), and only a particular diffraction pattern is of interest. In this mode, the CCD and processing circuits are operated to detect only diffraction at selected multiple beam energies and thus to discriminate against photons at all other energies. This mode is useful for diffraction experiments in which there is a need for fine adjustment of the x-ray beam energies to avoid strong absorption in the samples.

This work was done by David F. Blake, Charles Bryson, and Friedemann Freund of **Ames Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*

This invention has been patented by NASA (U.S. Patent No. 5,491,738). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-12043.

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Mid-Infrared Detector Subsystem for On-Line Process Monitoring and Other Applications

Revolutionary changes in the measurement of chemical processes on-line have been demonstrated in the plant by the use of this miniature linear array detector. It operates in the mid-infrared (2-14 micron band) and offers the significant advantage of room temperature operation. The detector can be provided as a component, as a board with ASIC-based signal processing, or as a complete subsystem delivering serial data to a PC. The technology is of broad interest for mid-infrared detection and analysis.

Competing technologies either require cooling or are still at an early research stage. This one enables the implementation of miniature mid-infrared instruments and systems. This has already been exploited in one application that took a measurement technique out of the laboratory and into the manufacturing plant. The detector provides 128 pixels in a linear array, and can be optimized for a specific wavelength within the 2-14 micron band. It can be supplied as an unmounted component, on a small PCB with associated ASICs to buffer the detector signal, or as a subsystem with power supplies and a local processor to convert the signal to a serial data stream in RS-422 format. The manufacturing process is well established and uses proven techniques developed from silicon device fabrication. The technology can readily be adapted to a different number of pixels to suit particular applications.

The detector was developed in a joint program between a major research laboratory and a chemical company. The technology has been developed to ensure a consistent high-yield manufacturing process, and initial applications in spectroscopy have demonstrated the excellent performance of the device and shown its clear advantages. The technology appears to be suitable for broader applications in the mid-infrared.

For more information go to
www.nasatech.com/techsearch/tow/detector.html
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Liquid Crystal Optical Element and Liquid Crystal Display Apparatus

A light-controlling device of this liquid crystal optical element without a pair of polarization plates may be used as a building material such as a window, a skylight, or a partition of a door, as a material for casting for various electrical products, or a door or closure. Furthermore, a projection type display apparatus using this type liquid crystal optical element is realized with a further bright image and less optical loss than that using a usual liquid crystal optical element, which requires a pair of polarization plates.

For more information go to
www.nasatech.com/techsearch/tow/liquid.html
email: nasatech@yet2.com; phone: 617-557-3837

PRODUCT GUIDE:OPTICAL MOUNTS

Optical mounts are the worker bees of the photonics industry. They come in swarms, they possess none of the glamour of other members of the family such as holographic optics and VCSELs, but they are the very foundation of an optical train or experiment. All of the manufacturers listed below have extensive lines of optical mounts, so that this guide does not purport to do anything more than suggest the range of the offerings.

The mounts are intended for the most part for holding and pointing lenses, mirrors, beamsplitters and other round and for the most part single-element optics. According to Newport Corporation, one of the leading providers of this kind of equipment, the main factors to consider in selecting a mount are adjustment type — that is, kinematic, gimbal, or flexure, transmission capability, and mechanical interface.

In a kinematic mount, the most commonly used method of providing two-axis rotation, the center of rotation is located off the optic's surface. For a gimbal mount, the center of rotation is precisely at the geometrical center and on the front surface of the optical component. Flexure mounts use solid springs to constrain the component's mounting plate. Melles Griot, another foremost purveyor of such components, asserts that kinematic and flexure mounts offer economical, precise positioning in spite of some cross-coupled motion. Because gimbal mounts provide angular adjustment without translation, they are employed in the most precise beam control applications, and are generally more expensive than kinematic mounts.

Mounts with a clear aperture are obviously suitable for use with transmissive elements such as beamsplitters, lenses, and filters. Platform mounts, with their solid front plate, are suited to reflective optics, and to adjust components mounted on their surface, such as prisms and beamsplitting cubes.

The material from which the mount is made is also important in choice. Aluminum, brass, and stainless steel all have their virtues and drawbacks, and the manufacturer should be consulted on which of these materials are best suited to your application.

NEWPORT CORP.
www.newport.com

Newport offers a wide variety of fixed, full-size and miniature kinematic, gimbal, and specialty mounts that can be mounted to posts, tables, and rails.

- The Ultima™ series is the company's top-of-the-line mount, utilizing interchangeable actuators. These stable kinematic mounts feature the company's patented clear quadrant design, and many optional mounting accessories are offered. Included in the series are mounts for sizes ranging from 0.5, 1, 1.18, 2.3 and 4 in. The clear quadrant of the front plate allows beams to pass close to the edge of the mounted optic, so that beams can be reflected from one mount to another at minimum incident angles and with minimum separation. Part numbers begin with U. There are more than 55 kinematic and 58 gimbal mounts in the series.
- The Ultima Corner Gimbal Optical Mounts are designed to tilt an optic without translating its surface by adjusting two adjacent actuators. Corner mounting allows an optic to be positioned in locations where space is at a premium. Newport says the mounts for 1-inch diameter optics are provided with 80 TPI adjustment screws, but the user can also use the base model and choose among several actuators.
- The Performa™ series are kinematic mounts for general laboratory or industrial applications. They are available for 1-inch diameter aperture optics as well as platform versions in sizes ranging from 0.5 and 0.75 to 1 and 2-inch optics. Precision 80 TPI adjustment screws with matching brass sleeves are standard on these mounts. Capstan knobs can enhance the position sensitivity of the mount by inserting a standard Allen wrench. An adaptor converts the mount to a post-mounted horizontal platform for mounting prisms, cube beamsplitters, and other components. These mounts are available in aperture optic sizes of 1 and 2 in., and in a 2-in. platform type. Part numbers begin with a P.
- The MFM series of flexure mounts comes in diameter sizes of 0.5, 0.75 or 1 in. The 80-pitch adjustment screws can be adjusted over a 3.5-degree range with an Allen wrench. The company offers a number of other specialty mounts: the GM series for orthogonal coplanar adjustments; the HVM series for vertical-drive kinematic adjustment; the VGM for vertical-drive gimbal adjustment; the 610 series ultra-resolution mirror mount; and several series of lens mounts and holders, in addition to many series of specialty optical mounts. New to the line is the RM25 polarizer rotation mount, allowing 1 in. diameter linear polarizers, wave plates, calcite polarizers, and polarizing cube beamsplitters to be continuously rotated 360 degrees.

MELLES GRIOT
www.mellesgriot.com

Melles Griot's MicroLab™ opto-mechanical system is designed for optical components that typically range from 5 to 15 millimeters in size. It includes mirror and beamsplitter mounts, lens, fiber and polarizer holders, and optical component cell systems. A series of optical mounting cells is also available to make handling easier.

- The kinematic mirror mount can be adjusted over an angular range of plus or minus 5 degrees. Mirrors of a diameter of 12.5 to 12.7 millimeters and 25 to 25.4 millimeters are attached to the mount using component holders. When mounted horizontally on top of a post, this black anodized aluminum mount becomes a prism or cube-beamsplitter tilt table.
- Gimbal and beamsplitter mounts provide plus or minus 2.5 degrees of angular adjustment about two orthogonal axes that intersect at the center of the optic's front surface. A retaining ring holds optics from 12.5 to 12.7 millimeters. Mirrors up to 6 millimeters in thickness and plate beamsplitters up to a millimeter in thickness can be mounted. The maximum transmitted beam diameter at a 45-degree angle of incidence for the gimbal beamsplitter mount is 5 millimeters.
- The flexure mirror/optic mount has three adjusting screws that yield plus or minus 2 degrees of tilt when one screw is turned and 1 millimeter of translation along the optical axis when all three are turned an equal amount. Melles Griot says that the mount's 16-mm-diameter aperture makes it unique. The flexure mirror/optics mount is made of brass with a black chrome finish and black anodized aluminum. An optical-cell rotation adaptor allows optics mounted in 16-mm-diameter cells to be rotated in the flexure mount.
- The company makes a variety of optical

component holders to mount 12.5-millimeter and 25-millimeter components to the kinematic mirror mount and flexure optics mount. The smaller component is mounted in a plate that attaches to the front face of the mount. Two versions are available: the standard version has an M2-threaded hole for post mounting, and the extended version is used with two kinematic mirror mounts when transmission is required. With 25-millimeter components, the optic is held against the front mount's surface by a plate that goes over the front face of the optic. It is attached to the mirror mount with four screws.

- A line of optical component cells is designed to hold lenses and other components for handling. The cells come in outer diameters of 10, 16, and 20 millimeters, covering a component diameter range of from 5 to 17.5 millimeters. Other holders include a gradient-index lens holder, a spherical ball lens holder, a microcomponent holder, a pinhole/slit holder, a filter holder and an adjustable lens holder. There are also two types of cell holders, one that attaches to a mirror/optics mount, and one with an integral base. An x-y positioner for optical component cells allows 16-millimeter-diameter cell-mounted components to be aligned in the x-y plane.
- A line of kinematic mirror/beamsplitter mounts has an angular range of 10 degrees. It is available with a ready-to-go mounted wavelength/4 flat mirror. Optics diameters that can be used with the mounts range from 12.5 to 50.8 millimeters. They come with either two or three adjusters. Also available is a line of flexure mirror/beamsplitter mounts. Sizes that can be used range from the MicroLab version (16 mm) to 50 mm. A group of flexure mirror mounts called Micropoint™ are machined from a single piece of hardened and tempered steel. Also available are a general-purpose gimbal mirror/beamsplitter mount as well as a research-grade mirror/beamsplitter mount. Holders are available for lenses, filters, and polarizers.

EDMUND INDUSTRIAL OPTICS
www.edmundoptics.com

Edmund Industrial Optics' line of mounting components has tapped holes and dimensions in the English standard (i.e., 1/4-20, holes on 1 inch centers) as well as mounting components in the metric standard (i.e., M6 threads, holes on 25 millimeter centers). But the company's thread-to-thread adapters eliminate the differences, and the adapter plates and metric-base plates are designed to be compatible with both English and metric standard breadboards.

- Edmund's kinematic optical cell mounts cover diameter ranges from 1-2 in. up to 12.5-12.625 in. They are also available for the company's C-mount and T-mount integrating mounting components. A ball pivot and 64-pitch screws (two 32-pitch for 8-12.5 diameter models). There is an angled series that offers an angled base for simple stand-alone installation. The straight series adapts to standard 1/4-20 TPI hardware. There are nine models in the angled series and five in the straight series. A line of precision gimbal mounts has coarse angular translation of 360 degrees and fine angular translation of 0.25-mm pitch. A 20-mm stainless steel metric post is included. There are four models in the series.
- The kinematic mounts series has three models, with sizes of 25.4, 50.0, and 50.8 mm. A set screw holds optics in place. There are two color-coded knobs for pitch and roll. The top-mounted micrometers do not interfere with system integration.
- Edmund offers a self-centering jaw clamp and gimbal mount for use with components up to 4-1/4 in. diameter. The clamp is mounted alone on the 1/4-20 tapped hole in the base or to the 6-in. gimbal frame. The gimbal mount has an angled base to allow fastening by 1/4-20 cap screws or unfastened standalone use. The mount features two-axis tilt with orthogonal three-point suspension. Three 64-pitch screws permit adjustment.
- A line of polarizer mounts has three standard and one micrometer-driven models. They have a secure optic retainer, a lever arm for smooth rotation, a locking knob for repeatability, and 360-degree scaled vernier. For the micrometer-driven version, the total travel of the 0.25-mm pitch fine adjustment is 10 degrees.
- Edmund offers a fixed/multiple filter mount that allows stacking of up to four filters. It comes in two models with a retaining ring that holds the filter in place. A matching mounting cell sits securely in the filter holder.
- Among other devices available are metric rectangular optic mounts, a metric spring/mount filter holder, a prism holder, and a rotary assembly with a prism holder. A kinematic mirror mount holds 1-in. and 2-in. diameter mirrors. The company also offers an adjustable gimbal mirror mount with movement by means of two fine 80-pitch screws, permitting 7-degree tilt in two planes. Also available are miniature, small, and large straight and angle mounts, and optical fiber alignment mounts.

COHERENT
www.coherentinc.com

Coherent's standard stock includes a wide variety of precision optical mounts and hardware, as well as translation components, optical tables and rails. TopAdjust kinematic mirror mounts are available in many sizes ranging from 1 in. square to 3 in. square. Both tip and tilt controls are top mounted to avoid beam contact where access is restricted or it is necessary to keep the operator's hands away from the optical path, as in high-power systems. TopAdjust mirror mounts are available with bases for metric or inch table mounting or without bases for post-mounted applications. The fine pitch adjusting screws are fitted with knurled locking rings to prevent accidental movement once set in place. Angular adjustment range is plus or minus 2 degrees.

- Coherent markets Precise™ 1-in. mirror mounts designed to accept round mirrors or beamsplitters up to 25.4 millimeters in diameter. Holes in the backplate are designed to accept almost all hardware. Angular adjustment range is plus or minus 10 degrees. The 100-thread-per-inch adjusters have the hex key option.
- The company also offers kinematic mirror mounts for round, front-surface mirrors or beamsplitters of either 3 or 4 in. diameters. Optics are retained in the mount by two delrin inserts and a nylon-tipped set screw. Angular adjustment range for the 3-in. mount is plus or minus 12 degrees, and for the 4-in. plus or minus 10 degrees. Clear aperture on the 3-in. mount is 73.0 millimeters and for the 4-in. 97.5 millimeters.
- Available from Coherent are compact mirror mounts that will accept square or round (cell-mounted) mirrors in 1-in. or smaller sizes. A wide range of cells is available for mounting round mirrors on the face of these mounts. Angular adjustment range is plus or minus 15 degrees.
- A line of lens and optical component mounts is also available from Coherent. These are fixed position post-mounted component holders. They are available in a range of sizes from 0.5 in. diameter to 4 in. diameter. Lenses, filters, mirrors and windows can all be held in these mounts.
- The company also offers adapters for a range of mounts; fixed threaded lens mounts; kinematic prism and beamsplitter platforms; beam height risers for Precise mounts; 145-degree adapters; and a variety of beam steering devices, among other instruments.

OPTOSIGMA
www.optosigma.com

OptoSigma markets a broad range of mirror mounts of both the kinematic and the gimbal variety. Large precision mirror mounts are available for 4, 6, 8, and 10-in. diameter mirrors, and larger sizes are available on request.

Sensitivity is less than 3 arcseconds. Mirrors are held in a mounting ring by means of three clamp screws. Angular alignment can be made about two axes, by means of dual-action adjusters with fine screw and ultrafine differential micrometer action.

- OptoSigma offers its UltraStable™ mirror mounts for 1 and 2-in. diameter mirrors. Adapters can be used for other sizes. Mirrors are secured in place from the rear of the mount using a retaining ring. Two degrees of freedom about the azimuthal and elevational axes are driven by a dual-speed differential micrometer.
- A line of gimbal mirror and beamsplitter mounts have full 360-degree rotation around the mirror surface. Once roughly set, the mount may be locked and fine motion controlled by the micrometer adjusters for both azimuth and elevation. These mounts accept 2-in. (50-mm) or 30-mm diameter beamsplitters and provide a clear aperture at 45 degrees of 1-in. and one-half inch respectively. The line has six mirror mounts and two beamsplitter mounts available.
- OptoSigma makes mini-beamsplitter mounts available. These permit a 45-degree incident beam to pass unimpeded through the mount. They accommodate only 15-mm diameter beamsplitters of thickness up to 2 millimeters, providing a 6-mm diameter clear aperture at 45 degrees. They have two top-projecting screws to provide plus or minus 2 degrees of tilt over two axes.
- The company's TopMike™ mirror mounts have the tilt controls top-mounted within the width of the mirror mount. The mirror can be adjusted in two axes of tilt. The TopMike is normally supplied with a base that sets the mirror normal to the optical path, but two other mounting options are available, one being at 45 degrees to the incident path. There are five models available.
- OptoSigma also offers the OneTouch™ mirror mount. The user simply touches a spring-loaded button on the side of the mount, inserts the mirror, releases the button, and the mirror is held securely in an adjustable mount. Cutouts in the side of the mount make it possible to avoid touching the mirror. A slight noncircularity in the mounting aperture ensures kinematic sealing and allows for a slight variation in diameter to accommodate both inch and metric diameters. Fine-pitch 100 TPI (0.25-mm) screws provide stable and controllable adjustment in two perpendicular axes of tilt.
- Other products available from the company include flexure mirror mounts, small mirror mounts, mini-mirror mounts (10, 12.7, and 15 mm in thicknesses of 3 to 6 mm), five- and three-axis optical mounts, polarizer holders and pinhole mounts.

THORLABS
www.thorlabs.com

Thorlabs offers a six-axis kinematic mount (K6X) designed for such applicatiions as crystal alignment, lens alignment for diffraction-limited performance, and fiber optic coupling. Also available is a prism mounting attachment designed to provide a half-inch by 1.44-in. platform mounted to the rotation stage of the K6X. The K6X1 comes with prism-mounting hardware, hex key and mounting screws.

- Thorlabs says its gimbal mirror mounts for 1-in. and 2-in. mounts are true gimbal design because the optical surface is located on the rotating axes. Their graduated adjuster knobs have 50 divisions per revolution. The hardened steel drive mechanism provides long-term stability, according to the company.
- Also available from Thorlabs are kinematic mounts for optics with 1/2, 1, 2, 3, and 4 in. diameters. The company offers a vertical-drive mirror mount for 1-in. optics, with a total travel of plus or minus 3 in. A piezoelectric kinematic mount combines the mechanical features of a kinematic mirror mount with the electromechanical of a piezoelectric stack. The stacks are mounted in the front plate, directly under the tips of the three adjuster screws, allowing for coarse and fine control of both the translation and the angle of the front plate.
- Also available are mounts for thin 1-in. and 2-in. optics, a kinematic prism mount, and a kinematic platform mount. Among mounts for lenses are those with diameters for 0.5, 1, 1.5, and 2-in. diameter lenses. A self-centering lens mount has three spring-loaded fingers that automatically grip optics ranging from 0.15 in. to 1.70 in. The lens holder fingers are opened with one hand by pinching the actuator tabs between the thumb and forefinger. The spring-loaded fingers firmly grip the optic while the cam action of the nested ring design centers the optic.
- New to the line is a cylindrical lens mount that accepts cylinders up to 65 millimeters tall. Thorlabs says that, unlike most guillotine mounts, there are no objects in its design to block the optical axis. Also available is a high-precision rotation mount that combines easy-to-use manual rotation with backlash-free micrometer adjustment, according to the company.

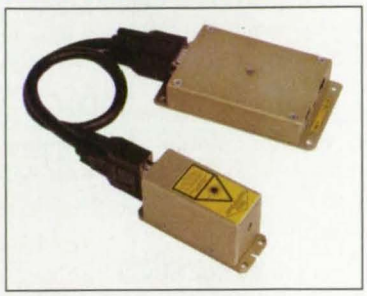
CVI LASERS
www.cvilaser.com

CVI Laser offers several lines of rotary mounts intended for optics of diameters of 0.5 through 3.0 in. The Model1180 allows the user to make quick coarse adjustments followed by an extremely fine tweaking. With the locking screw disengaged the 1180 operates like an ordinary rotary mount, allowing full 360-degree rotation. With the thumbscrew engaged, turning the adjustment screw provides 20-microradian per degree adjustment over a plus or minus 5-degree total rotation range.

- Mirror mounts are available for all standard mirror sizes from 0.5 to 4.0. New to the line are rectangular mirror/prism mounts, which hold right-angle prisms and rectangular or square mirrors, providing, according to CVI, very large clear apertures. CVI's Series 200 has 16 models to choose from, for sizes ranging from 0.5-in. diameter to 2.0 in. diameter. CVI says its Series 310 is its largest and highest-resolution mount, with models for 2.0, 3.0, and 4.0 optics. The mounts are made of hardened steel with lapped carbide bearing points and 80-pitch adjustment screws.
- Also available are series of rectangular mirror/prism mounts, a three-axis prism mount, lens centering cells, filter wheels, lens mount right-angle plates, and many other optics holders.
- CVI calls the Series 8800 super mount a completely innovative concept. The mainframe is a heavy fixed plate with three 80-pitch adjustment screws and a tiltable contoured frame with a pair of precision machined dovetails. Individual optic carriers clamp to these dovetails. The beam height is no longer built into the mount; the 8800 makes it adjustable. And the same mainframe may hold many different types of carriers. Some of the devices that may be fashioned with the 8800 are a vertical-plane ring resonator, a Michelson interferometer, and a reflective beam expander with astigmatism compensation.

New Products

Product of the Month



DPSS Laser for Biomedical Market

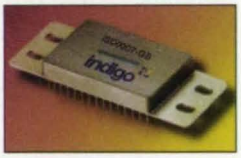
JDS Uniphase Commercial Lasers, San Jose, CA, announces the S series (CDPS532-S), a continuous-wave 532-nm laser for OEM integration into biomedical instruments. The product is half as large as previous designs, and features a controller that requires less power and produces less heat than other available models, according to the company. The S series is a single-longitudinal-mode frequency-doubled Nd:Vanadate diode-pumped solid-state laser. It provides an output power of 10 mW with less than 0.5 percent noise. The device has a 76- × 28.5- × 40-mm head and a 111- × 63- × 22-mm controller. JDS expects the laser to have applications in the biomedical industry that would include use as an illumination source for instruments such as DNA sequencers and flow cytometers.

For Free Info Circle No. 750 or Enter No. 750 at www.nasatech.com/rs

Precision Molded Glass Components

Docter Optics, Mesa, AZ, offers precision molded standard optical components in rectangular, square, or diameter sizes from 4 mm to 165 mm. Components include aspheric condenser and spherical singlet lenses, concave first surface mirrors, heat-absorbing filters of Schott B270 Superwite® crown, 8830 Duran® borosilicate, F2, Pyrex, KG1 or KG2 colored glass materials, single- or multilayer AR, cold light, dichroic, IR and metallic aluminum coated devices. Custom components are available in sizes up to 260 mm and include IR and neutral density filters.

For Free Info Circle No. 752 or Enter No. 752 at www.nasatech.com/rs



1024-x-1 Linear InGaAs Array

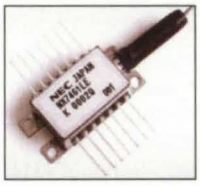
Indigo Systems Corp., Santa Barbara, CA, introduces the ISC0007-GS1024, which it calls the world's first 1024-x-1 linear InGaAs photodetector array for telecommunications and NIR spectroscopy applications. The instrument combines the company's readout integrated circuit, InGaAs detectors, and bump-bonded hybridization techniques, all fashioned in-house. Indigo says the array is specifically designed to meet the rigorous demands of DWDM optical quality monitoring, providing both ultrahigh spatial resolution and very wide dynamic range.

For Free Info Circle No. 755 or Enter No. 755 at www.nasatech.com/rs

Diode Laser Mirrors/ Line Reflectors

Edmund Industrial Optics, Barrington, NJ, is offering new laser mirrors and high-power laser line reflectors. The mirrors are manufactured from fused silica with a dielectric coating, and are recommended for beam steering visible and near-IR lasers in the kilowatt power range, such as fundamental and frequency-doubled Nd:YAG lasers. They feature high reflectance of greater than 99.8 percent and a damage threshold of 20 J/cm^2. They are available in two diameters, 12.5 mm and 25.0 mm, and feature surface accuracy of a tenth of a wave at 632 nm.

For Free Info Circle No. 758 or Enter No. 758 at www.nasatech.com/rs



1480-nm Pump Laser Sources

California Eastern Laboratories, Santa Clara, CA, introduces the NX7461LE and NX7462KE, two new 1480-nm pump laser sources from NEC. Designed for erbium-doped fiber amplifiers deployed in DWDM ultra-long-haul, long-haul, and metro networks, the devices have output powers of 550 mA and 600 mA respectively and operating temperature ranges of -20 to +70 degrees C. Housed in hermetically sealed 14-pin butterfly packages, these modules combine an InGaAs FP laser diode with an internal optical isolator, a thermoelectric cooler, and an InGaAs monitor photodiode.

For Free Info Circle No. 753 or Enter No. 753 at www.nasatech.com/rs

Tabletop Microelectronics Machining System

New Wave Research, Fremont, CA, introduces AccuLaze™, a compact tabletop machining system designed for such applications as thick- or thin-film resistor and capacitor trimming, hole drilling, LCD repair and materials marking and etching. Each system includes an Nd:YAG laser, a high-magnification video system, and control software. It is available in six different wavelengths from deep UV (213 nm) to IR (1064 nm), enabling users to match the wavelength to the absorption level of the material to be processed.

For Free Info Circle No. 756 or Enter No. 756 at www.nasatech.com/rs

Miniature Neon Lamps

Gilway Technical Lamp, Woburn, MA, says its line of ruggedized miniature neon lamps was designed for indicator applications requiring operation directly from 110/220 VAC. Available in standard red and green colors, with or without a series resistor, they provide brightness up to 5.0 mcd. They measure only 3.2 mm to 6.0 mm in diameter, they can also operate from greater than 90 VDC, and are rated for 15,000 to 50,000 hours of operation. These Gilway lamps are filled with either a neon-argon gas mixture or pure neon gas, depending upon model.

For Free Info Circle No. 759 or Enter No. 759 at www.nasatech.com/rs

Modular Triple Spectrograph Systems

Acton Research Corp., Acton, MA, is offering the TriplePro™ modular triple spectrograph system. Based on its SpectraPro® spectrometer system, TriplePro incorporates a 300-mm double subtractive monochromator as the prefilter, with a high-performance triple grating SpectraPro 500 spectrometer as the final dispersing stage. Equipped with two exit positions on the output stage, TriplePro is ideal for Raman spectroscopy applications, according to the company. The instrument incorporates Acton Research's SpectraSense data acquisition software.

For Free Info Circle No. 751 or Enter No. 751 at www.nasatech.com/rs

Laser Distance-Gauging Sensor

Banner Engineering Corp., Minneapolis, MN, is offering the L-GAGE® LT3 time-of-flight sensor, which the company says is a Class 2 laser distance-gauging device that can measure at long ranges up to 50 meters (164 feet). The LT3 has a measurement resolution of 1 mm (0.04 in.). The range for gray targets is 0.3 to 3 m (1-9.8 ft.) and for white targets 0.3 to 5 m (1-16.4 ft.); a retroreflective model is available for applications that require sensing range up to 50 m. The device features a modulated visible red sensing beam, and both a discrete (switched) output and an analog output, or both simultaneously. Output response speed is programmable to 1, 10, or 100 milliseconds.

For Free Info Circle No. 754 or Enter No. 754 at www.nasatech.com/rs

Eyesafe Laser Rangefinder Receiver

Analog Modules, Longwood, FL, says the rugged, compact construction of its Model 759 hybrid eyesafe laser rangefinder receiver makes it suitable for handheld, vehicle-mounted or airborne applications. The Model 759 uses an advanced preamplifier design to achieve a sensitivity of 40 nW at 1550 nm with 20-ns pulses. Pulsewidths from 6 to 40 ns are processed over six orders of magnitude of dynamic range, and operation is possible from 1.0 to 1.6 micrometers.

For Free Info Circle No. 757 or Enter No. 757 at www.nasatech.com/rs

DPSS Q-Switched Lasers

Laservall North America, Pawtucket, RI, is introducing the Violino™ line of continuous-wave, Q-switched (up to 300 kHz) Nd:YAG/YVO_4 diode-pumped solid-state OEM laser sources. The line comes in compact models with 5, 10 and 20 W output at 1064 nm. The Violino is air-cooled and requires no external chiller, and has an average diode life of 10,000 to 15,000 hours. It is available as a marker package, with scanning head, DSP control card, and laser marking software. Laservall recommends the unit for marking, engraving, microvia drilling, scribing, ablation, and more.

For Free Info Circle No. 760 or Enter No. 760 at www.nasatech.com/rs

InP HEMT MMIC Low-Noise Amplifier for 65 to 110 GHz

Copies performed substantially as designed in cryogenic and room-temperature tests.

NASA's Jet Propulsion Laboratory, Pasadena, California

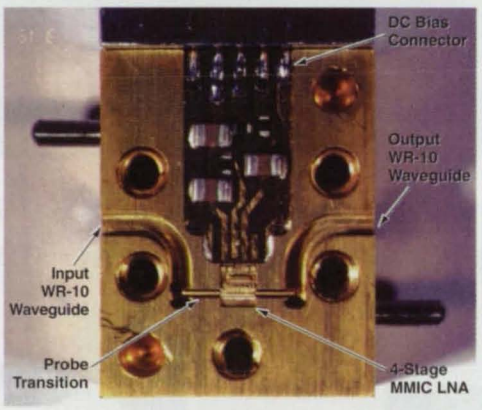
A monolithic microwave integrated circuit (MMIC) has been designed to function as a low-power-consumption, low-noise amplifier (LNA) at frequencies from about 65 to about 110 GHz. This MMIC incorporates TRW's state-of-the-art, InP-based, high-electron-mobility transistors (HEMTs) coupled with coplanar-waveguide (CPW) transmission lines, thin-film resistors, and thin-film capacitors. The MMIC is mounted in a waveguide module with CPW-to-waveguide transitions of the probe type (see figure).

An unusual feature of the circuit is a path for a pilot signal with a typical frequency of 500 MHz. This path is through the same transistors used to amplify the millimeter-wave signal. The pilot signal is applied through a pilot input terminal (the upper left pad in the figure) and appears at a pilot output terminal (the upper right pad in the figure). The low-level pilot signal is coupled from one bias circuit to the next and does not interact appreciably with the millimeter-wave signal. The pilot signal is meant to be used to measure fluctuations in the gain of the transistors; such measurements are useful in applications (e.g., radiometry) in which fluctuations in gain can affect measurements.

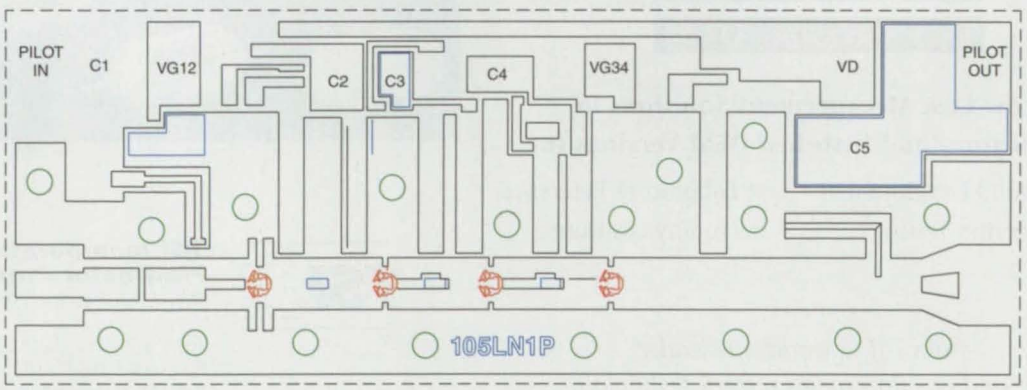
The MMIC is designed to operate in the presence of cooling by a suitable cryogenic apparatus. Seventeen waveguide modules containing copies of the MMIC were tested for noise temperature by use of a variable-temperature waveguide with a 20-dB attenuator and a precise diode temperature sensor. The range of noise temperatures over the 85-to-115-GHz frequency range was found to be 30 to 107 K at an operating temperature of 24 K. The noise at room operating temperature was found to range from 250 to 470 K. In other tests, the MMICs were found to be capable of producing 20 dB of gain while consuming as little as 1.4 mW of dc power.

This work was done by Todd Gaier and Sander Weinreb of Caltech, Neal Erickson of the University of Massachusetts, and Richard Lai of TRW for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*

NPO-20752



MODULE CONTAINING AMPLIFIER



MAGNIFIED LAYOUT OF AMPLIFIER

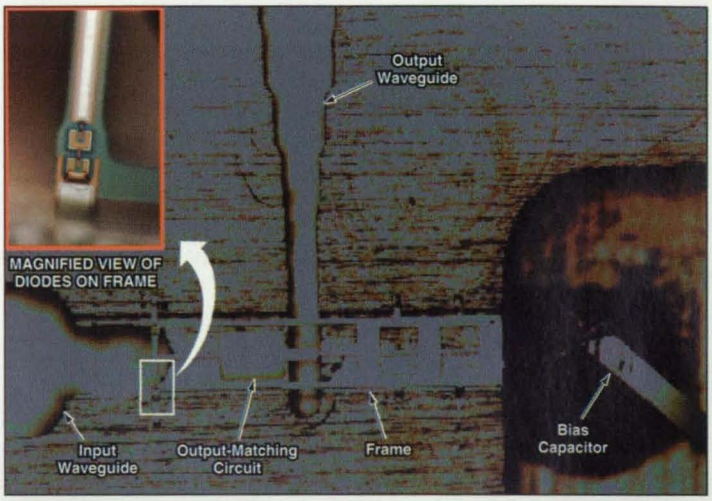
A **Four-Stage MMIC LNA** is mounted in a split-block waveguide module. The dimensions of the MMIC chip are 2 by 0.73 by 0.075 mm.

"Substrateless" Millimeter- and Submillimeter-Wave Circuits

Radio-frequency losses are reduced by suspending conductors in air.

NASA's Jet Propulsion Laboratory, Pasadena, California

Monolithic integrated circuits (in particular, Schottky-diode-based frequency multipliers) that operate at frequencies as high as a few terahertz are being developed in a program that utilizes the recent advances in methods of computer-aided design and microfabrication. In the approach followed in this program, the active semiconductor devices (GaAs-based Schottky diodes) in a frequency-multiplier circuit are integrated with passive devices (planar metal transmission lines). To reduce radio-frequency losses associated with dielectric layers in the passive circuitry, the semiconductor substrate under the transmission lines is etched away, leaving metal conductors insulated by air and held only by their edges on a semiconductor frame. The monolithic integration makes the integrated circuit larger (in comparison with discrete circuit components that one would otherwise have to assemble), thereby making the circuit more robust and easier to handle in fabrication and mounting. Metallic beam-leads are used extensively, serving as (1) mechanical handles that facilitate handling and mounting, (2) current paths for dc grounding and biasing of the diodes, and (3) thermal conductors. Moreover, this approach enables the precise positioning of the diodes with respect to the rest of the circuitry and facilitates scaling for operation at higher frequencies.



A **"Substrateless" 400-GHz Frequency Doubler** is mounted in a crossed-waveguide block for testing.

Following this approach, a frequency multiplier is designed in a three-stage process. In the first stage, one uses (1) a computer program that simulates nonlinear circuits and (2) a computer program that

implements a mathematical model of a diode in conjunction with a harmonic-balance-based simulator computer program to optimize the dimensions, doping profile, and number of diodes to be used in the circuit. This stage yields the diode-junction characteristics and embedding impedances that give the best performance.

In the second stage, the input and output impedance-matching transmission line circuits are designed by use of finite-element electromagnetic-simulator software. The numerical output of this software comprises scattering-parameter matrices referenced to diode and transmission-line ports. The matrices plus the embedding impedances computed by the nonlinear-circuit simulator software are then provided as input to linear-circuit simulator software, which is used to analyze the impedance-matching effectiveness of the input and output transmission-line circuits. The parasitics associated with the diode(s) are included in this analysis as part of the passive circuit.

To simplify and speed up the analysis, the passive circuitry is divided into small elements at electromagnetically appropriate points, giving rise to several S-parameter matrices. Ports are modeled as being attached to probes on each anode so that the individual embedding impedance for each diode can be calculated directly. The diodes are then modeled as being embedded into the resulting cascaded S-parameter matrix blocks to determine the total efficiency and the power performance of the multiplier. If these are unsatisfactory, relative to the intrinsic efficiency and performance of the diodes, the circuit design is iteratively modified to correct for the parasitics found in the simulation.

Standard processing techniques, including stepper lithography and reactive-ion etching, are used to fabricate the diode structures on the front side of a GaAs wafer. The diodes are located on an edge of that portion of the GaAs wafer that is destined to remain as a transmission-line-supporting frame. After front-side processing has been completed, a back-side procedure is used to remove the GaAs under the metal conductors of the input and output transmission lines, except for edge supports as described above.

Thus far, two types of frequency-doubler circuits, designed for output frequencies of 200 and 400 GHz, respectively, have been designed, fabricated, and tested (see figure). Notwithstanding a need for further iteration to optimize design, the results of the tests are encouraging: For example, in a test in which the input frequency ranged from 179 to 212 GHz, one of the 400-GHz units exhibited a peak efficiency and peak power of ≈15 percent and ≈ 6 mW, respectively, at an output frequency of 369 GHz at room temperature. This represents a new performance record from planar Schottky diode varactors at this frequency.

This work was done by Imran Mehdi, Suzanne Martin, Jean Bruston, Erich Schlecht, and R. P. Smith of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Compontents and Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-21080, volume and number of this NASA Tech Briefs *issue, and the page number.*

Capacitors Containing Nanocrystalline $BaTiO_3$ as Dielectric

Energy densities, breakdown potentials, and resistances exceed those of prior $BaTiO_3$-dielectric capacitors.

John H. Glenn Research Center, Cleveland, Ohio

Capacitors in which the main dielectric layers are made from sintered nanocrystalline $BaTiO_3$ have been fabricated and tested in an initially successful and continuing effort to increase energy densities, breakdown potentials, and insulation resistances beyond those of prior commercial capacitors that contain coarser-grained sintered $BaTiO_3$. This development effort is based on the premise that the relevant physical properties of $BaTiO_3$ grains vary with their sizes in such a way that smaller grains are better suited for use as dielectrics in capacitors.

The variations in question can be summarized as follows:

- Capacitance and Energy-Storage Density: For reasons too complex to be explained in the limited space available for this article, hysteretic switching of ferroelectric domains in $BaTiO_3$ gives rise to a loss of capacitance and thus a loss of incremental energy-storage density with increasing applied potential. It had been conjectured that this detrimental effect of ferroelectric-domain switching could be minimized by reducing grain sizes to the nanocrystalline range (<100 nm). Thus, it should be possible to store more energy, especially near the upper limit of applied voltage for a given capacitor.
- Breakdown Potential and Energy-Storage Density: The breakdown potential of $BaTiO_3$ or another ceramic dielectric material is related to its mechanical strength, which is approximately inversely proportional to the square root of the size of its smallest internal flaw. Inasmuch as the flaw size cannot be smaller than the grain size, it is expected that, along with mechanical strength, the breakdown potential should increase with decreasing grain size. The expected increase in the breakdown potential would contribute, along with the expected increase in capacitance, to an increase in achievable energy-storage density.
- Insulation Resistance: The insulation resistance of a capacitor is quantified by measuring the direct current that it passes when charged to a steady potential. A simplified electric model of a grainy dielectric material is that of grain-boundary and grain-interior elements in series. In a nanocrystalline (grain sizes less than about 100 nm) dielectric, more inherently resistive grain boundaries are present per unit thickness than are present in a coarser-grained version of the same material, and thus one expects the insulation resistance to be greater.

In preparation for testing these concepts, multilayer capacitors that contained sintered nanocrystalline dielectric layers were fabricated. The nanocrystalline dielectric materials were formulated to satisfy an Electronics Industries of America (EIA) standard, called X7R, that specifies acceptable ranges of dielectric properties as functions of temperature. Each grain of the

Property		Capacitors Made From Nanocrystalline $BaTiO_3$	Commercial Capacitors Made From Coarser-Grained $BaTiO_3$
Grain Size		<100 nm	0.5 μm
Relative Permittivity		1,815	2,498
Insulation Resistance at Applied Potential of 200 V	at Temperature of 25 °C	1,240 GΩ	132 GΩ
	at Temperature of 200 °C	730 MΩ	138 MΩ
Dielectric Breakdown	Potential/Thickness	863 V/8.75 μm	744 V/17.3 μm
	Electric Field Equiv. to Potential/Thickness	98.6 V/μm	43.0 V/μm
Energy-Storage Density at Half of Average Breakdown Potential		3.20 J/cm^3	1.86 J/cm^3

The **Nanocrystalline-$BaTiO_3$ Capacitors** were tested along with commercial $BaTiO_3$-dielectric capacitors and found to be superior with respect to insulation resistance, dielectric-breakdown electric field, and energy-storage density.

X7R-compliant $BaTiO_3$ has a duplex microstructure comprising a lightly doped ferroelectric core surrounded by a heavily doped paraelectric shell. (The dopants are Bi, Nb, Zn, and Mn).

The table presents results of tests of capacitors made from one of the nanocrystalline-$BaTiO_3$ formulations and of commercially available capacitors made from coarser-grained $BaTiO_3$. These results clearly indicate the superiority of the nanocrystalline $BaTiO_3$ as the dielectric material. On the basis of these results and of other observations made during the tests, it appears that in comparison with capacitors made from coarser-grained $BaTiO_3$, capacitors made from nanocrystalline $BaTiO_3$ can operate more reliably at high temperatures and high voltages, can be made smaller and lighter for a given capacitance value, and can have higher energy-storage densities and higher capacitances for a given case size.

This work was done by John Freim and Yuval Avniel of Nanomaterials Research Corp. for **Glenn Research Center.**

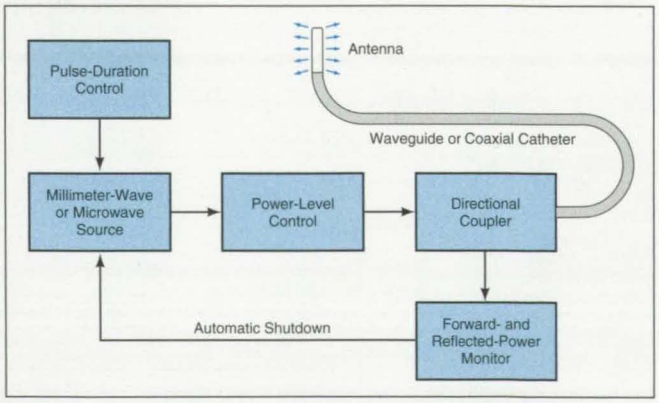
Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16984.

Millimeter-Wave and Microwave Treatment of Atherosclerosis

Controlled temperature profiles are generated to treat diseased coronary arteries without injuring them.

Lyndon B. Johnson Space Center, Houston, Texas

Millimeter-wave/microwave ablation (essentially, heating by use of millimeter-wave and microwave electromagnetic radiation) has been proposed as a means of treating atherosclerotic lesions. Computational simulations have shown that by controlling and customizing temperature profiles in millimeter-wave/microwave ablation, it should be possible to (1) treat atherosclerosis or coronary thrombosis without (2) incurring the distensions and injuries to arterial walls and epithelial walls that are common to current invasive treatments, while (3) possibly reducing post-treatment inflammation and even restenosis. Although millimeter-wave/microwave ablation has yet to be proved in tests on live animals, it offers the potential to signifi-



An **Antenna on the Tip of a Catheter** would radiate millimeter-wave or microwave energy to heat atherosclerotic lesions.

cantly advance the state of the art. Indeed, after further testing, millimeter-wave/microwave ablation might be used by cardiologists during balloon angioplasty replacement procedures (PTCAs) or coronary catheterizations. Because it is expected to be safer and more effective than traditional methods, millimeter-wave/microwave ablation could soon supplement or even supplant today's treatment choices.

In millimeter-wave/microwave ablation, electromagnetic energy would be delivered via a catheter to a precise location in a coronary artery for selective heating of a targeted atherosclerotic lesion. Heating to controlled, customized temperature profiles could be used to treat lesions in the intima and media layers of an artery wall, yet the most superficial endothelial cell layer and the outer adventitial layer would be preserved. Preservation of the endothelial cell layer is necessary to prevent thrombotic, inflammatory, and proliferative processes (restenosis), which complicate angioplastic procedures.

In millimeter-wave/microwave ablation, advantageous temperature profiles would be obtained by controlling the power delivered, pulse duration, and frequency. For best results, the profile would be chosen so that the maximum temperature is delivered at the center of an atherosclerotic lesion and the temperature would decrease, uniformly in all directions, with distance from the center. The heating would favorably modify lipid-rich lesions that contain the inflammatory cellular infiltrates that are prone to rupture, and the rupture of which causes thrombotic artery occlusions (heart attacks).

The major components of an apparatus for millimeter-wave/microwave ablation apparatus (see figure) would include a millimeter-wave/microwave source, a catheter/transmission line, and an antenna at the distal end of the catheter. The source would generate millimeter-wave or microwave power at a controlled level up to 10 W, with a pulse duration between 0.1 and 10 s controlled to within 2 percent. A chosen frequency between 2 and 300 GHz could be used; a separate source would probably be needed for each frequency. The catheter/transmission line would deliver the power to the antenna.

The antenna would focus the radiated beam so that most of the millimeter-wave or microwave energy would be deposited within the targeted atherosclerotic lesion. Because of the rapid decay of the electromagnetic wave, little energy would pass into, or beyond, the adventitia. By suitable choice of the power delivered, pulse duration, frequency, and antenna design (which affects the width of the radiated beam), the temperature profile could be customized to the size, shape, and type of lesion being treated. By controlling temperature, one could limit (1) the damage to the endothelial layers and (2) the risk of overheating nondiseased tissue and proximal blood. For safety, the control system of the apparatus would provide automatic shutoff in the event of an inappropriate power level, excessive reflected power, unsuitable pulse duration, or heating beyond prescribed limits.

This work was done by Patrick Fink and G. D. Arndt of **Johnson Space Center;** *J. R. Carl and Reginald Beer of Lockheed Martin; George Raffoul of Hernandez Engineering, Inc.; and Philip Henry and Antonio Pacifico. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*

This invention has been patented by NASA (U.S. Patent No. 6,047,216). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22724.

Software

KPP — a Preprocessor for VHDL

KPP is a computer program that serves as a preprocessor for VHDL code. ["VHDL" signifies VHSIC Hardware Description Language, which is a language used by the United States Department of Defense for describing, designing, and simulating very-high-speed integrated circuits (VHSICs).] KPP is based on, and similar to, CPP, which is a preprocessing program for the C computing language. KPP adds certain features that are useful to digital design engineers but are lacking in VHDL. These include, most notably, a capability for nested looping. KPP also provides a number of standard functions for defining and undefining variables, incorporating contents of named files, conditional execution of instructions, and block comments. The use of KPP can enable faster coding and greater reuse of designs. KPP can run in the Windows 95, Windows 98, and Windows NT operating systems.

This program was written by Richard Katz of **Goddard Space Flight Center** *and I. Brill of Edutech, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*
GSC-14380

Software for Analyzing Valve-Actuator Performance

A computer program assists engineers in analyzing data on the performances of actuators of fuel and oxidizer valves in the main engines of the space shuttle. The program could be adapted to similar use in other settings in which, as in the space shuttle, valve actuators are instrumented to provide data on commanded versus actual actuator positions. The program acquires such data during a specified diagnostic procedure in which valves are opened and closed. The program processes the data and generates several indications of performance, including trend plots, delta command minus actual positions plots, ramp-rate plots, error-from-command plots, and the means and standard deviations of the plotted quantities. The advantage afforded by the program is that it gives more information than does a simple pass/fail testing criterion. By looking at engineering performance profiles generated by this program during tests performed at different times, the engineers can identify valves that are about to fail in time to replace them.

This program was written by Edwin A. Cortes of **Kennedy Space Center.** *For more information, contact the Kennedy Commercial Technology Office at 321-867-6224.*
KSC-12238

Software for Network Processing of Work Orders

The Electronic Portable Information Collection (EPIC) computer program is a computer system that processes work authorization documents (WADs). The EPIC System, which is also known as the Portable Data Collection System, comprises a central data server and portable data terminals. The central data server acts as the host on a local-area network and maintains the WAD data in Structured Query Language (SQL) and a database. The portable data terminals are desktop, laptop, and pen-based tablet computers that run, variously, the Windows 95 or Windows

NT operating system and are connected to the central data server via the network.

In the current process that the EPIC system is designed to replace, all data pertaining to a job to be done by a team of workers are recorded on one master paper copy of the WAD for that job. Each member of the team has a paper copy, on which is recorded information pertinent to the task(s) to be performed by that member. Entries on the paper documents are authenticated by use of ink stamps. The person who holds the master copy of the WAD is the only one who has immediate access to a complete record of all processing that takes place, including deviations incorporated into the WAD.

In the EPIC system, task steps, deviations, and other pertinent data are stored in the SQL database, which is read and written by use of the EPIC software. Stamping is performed electronically; that is, the aforementioned data include information that serves the purpose now served by ink stamps. By use of the EPIC software, WADs can readily be stored, retrieved, and run on-line.

The EPIC software includes the following modules:

- *Form Conversion Module*
  Prior to execution of the job described in a WAD, this module is used to extract the data from the WAD (which is a Microsoft Word document) and insert the data into the database.
- *Stamp Utilities Module*
  This module administrates the electronic stamps. It associates the electronic stamps with the data in the database, including the user's name, and the user's telephone, fax, office, and identification numbers. It also associates the stamp with the authentication image of the work stamp assigned to the person who performed the task to which the stamp pertains.
- *Report Generator Module*
  After completion of a job, this module generates an as-run report. The report includes all of the information from the original version of the WAD plus the stamps, notes, deviations, and other data that were entered during the job. The report is put into Portable Document Format (PDF); as such, it is a read-only document that can be searched. Clean reports, which consist of the original WAD plus deviations but no stamp or data entries, can also be generated.
- *Portable Data Terminal Module*
  This module provides a graphical user interface (GUI) for displaying the information on, and entry of information into the system from, the portable data terminal of a member of the team. A member can enter task data by use of a keyboard, mouse, or electronic pen. A member can alter work procedures by use of a deviation form through which the WAD can be edited and approvals for changes can be obtained. As information is thus entered via a portable data terminal, it becomes immediately available on all the other portable data terminals.

This program was written by Kathy Potter, John Lekki, and Carl I. Delaune of **Kennedy Space Center** *and Mike Kappel of Sentel Corp. For further information, see below.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to KSC-12172, volume and number of this NASA Tech Briefs *issue, and the page number.*

Testing Soil for Electrokinetically Enhanced Bioremediation

Data from tests provide guidance for *in situ* treatment.

John F. Kennedy Space Center, Florida

The term "prefield test" denotes an *in situ* test of contaminated soil in preparation for *in situ* treatment of the soil by a method called "electrokinetically enhanced bioremediation" (EEB). A prefield test yields data that are helpful in designing and operating an efficient and cost-effective EEB system.

EEB was described in "Engineered Bioremediation of Contaminated Soil" (KSC-12045), *NASA Tech Briefs*, Vol. 25, No. 7 (July 2001), page 58. To recapitulate: EEB involves the utilization of controlled flows of liquids and gases into and out of the ground via wells, in conjunction with electrokinetic transport of matter through pores in the soil, to provide reagents and nutrients that enhance the natural degradation of contaminants by indigenous and/or introduced micro-organisms. An EEB system includes injection and electrode wells, pumps, reservoirs of chemicals, and other components needed to control the movements of charged anionic and cationic as well as noncharged chemical species and micro-organisms through the ground.

It has been standard practice, in preparing to design systems for *in situ* treatment of contaminated soil, to perform bench-scale laboratory tests on samples of soil from contaminated sites to determine hydrogeological, physical, and chemical parameters of soils and contaminants. A prefield test yields additional information that cannot be obtained from a bench-scale test and thus makes it possible to design a superior treatment system for a specific contaminated site. The additional information pertains to electrical conductivity and other parameters that vary spatially because of spatial variations in such properties of the soil as porosity, density of packing of particles, and chemical properties of pore fluid/soil interfaces. The data from a prefield test make it possible to optimize such design and operating parameters as applied voltages and currents and the positions of electrode wells, in order to treat the contaminated soil efficiently and more nearly uniformly.

In preparation for a prefield test, one inserts multiple test electrodes at different locations dispersed over the soil region of interest. At least one test electrode must be an anode and at least one must be a cathode (see figure). During the test, known dc voltages and currents are applied to the soil via the test electrodes. Voltage probes are inserted in the soil at various depths and at numerous horizontal positions between the test electrodes. The voltage readings as functions of position are used to generate a three-dimensional map of the test electric field.

The inhomogeneities of the test electric field are related to the inhomogeneities of the soil and the positions of the test electrodes, and can be used to guide the subsequent placement of working electrode wells for remediation of the soil. A rule of thumb calls for the placing of the working electrode wells so that at locations far from the electrode wells but still within the region of soil to be treated, the electric field should be at least 10 to 20 percent as strong as the electric fields near the electrode wells.

Other parameters can also be measured during a prefield test:

- It can be useful to measure the temperature of the soil at various positions between the test electrodes and the temperatures of the test electrode wells as functions of applied currents.
- The volumes of fluids in the electrode wells can be measured over time to determine rates of electro-osmotic

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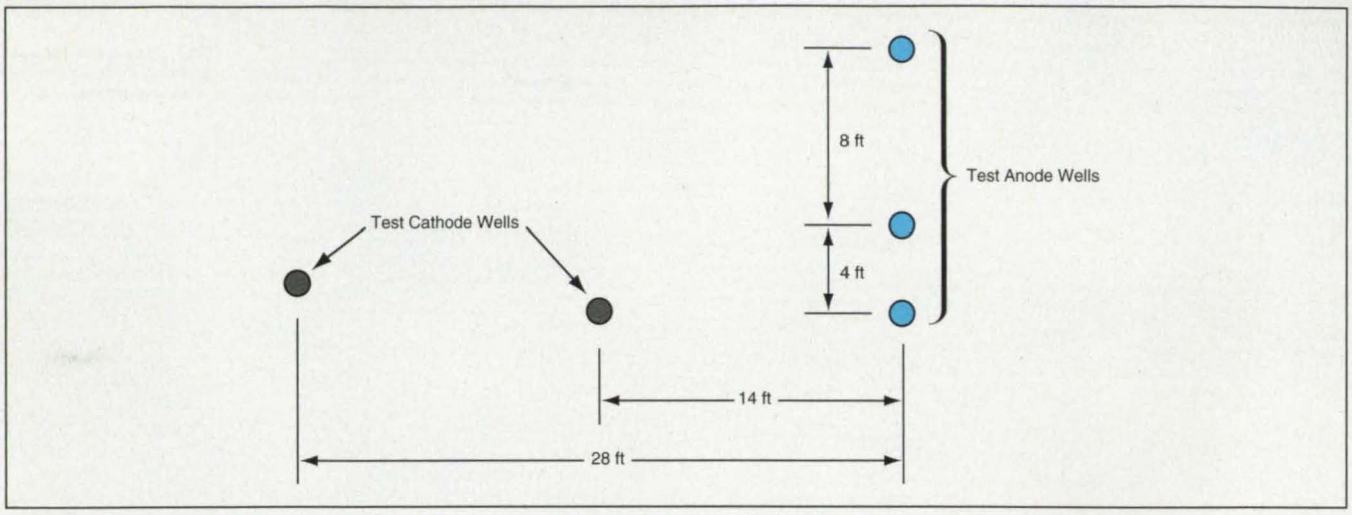

Test Cathode and Anode Wells can be positioned in this pattern or any of a variety of other patterns, depending on the size and nature of the soil region of interest. The minimum number of electrode wells needed for a prefield test is three.

flow through the soil. It may also be useful to track rates of electro-osmotic flow functions of applied voltages.

- Voltage drops across electrode-well walls can be measured for use in determining the optimum well-wall materials for particular soil conditions.
- The pH of the soil near a test electrode well can be measured while releasing a pH-adjusting solution from the well at a known rate. The result of this measurement provides guidance for adjusting the pH of the soil during treatment.

This work was done by Dalibor Hodko of Lynntech, Inc., for **Kennedy Space Center.** *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com/tsp*** *under the Materials category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to KSC-12160, volume and number of this NASA Tech Briefs *issue, and the page number.*

Software for Designing Actively Controlled Structures

One program offers capabilities heretofore available only in separate programs.

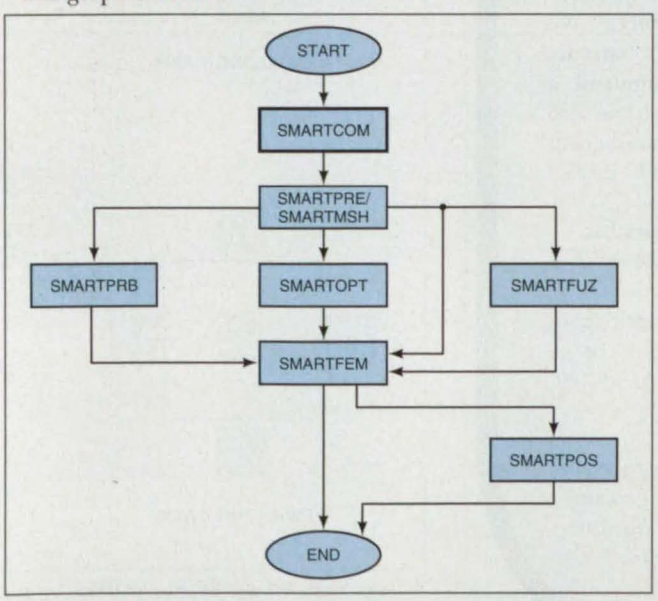
John H. Glenn Research Center, Cleveland, Ohio

SMARTCOM is a computer program for the analysis and design of actively controlled "smart" structures. Typically, an actively controlled "smart" structure incorporates piezoelectric sensors and actuators that are used, in conjunction with an electrical control system, to damp vibrations. As is the case for other structures, the analysis and design of actively controlled "smart" structures is often best accomplished with the help of finite-element computer programs. Unfortunately, prior finite-element codes do not offer coupled analyses of the mechanical, electrical, and thermal properties of "smart"-structure materials. Also, they are not directly linked with control software, making it necessary to use separate finite-element and control programs to analyze controlled structures. Furthermore, the programs used heretofore to design "smart" structures do not offer capabilities for optimization or for probabilistic or fuzzy analysis.

In contrast, SMARTCOM offers all of the needed functions and capabilities in one package. SMARTCOM can be used for finite-element modeling of electrical, mechanical, and thermal effects. It includes control algorithms for active damping, algorithms for optimizing the designs of structures, and algorithms for fuzzy and probabilistic modeling of uncertainties.

SMARTCOM comprises several modules that are used, variously, simultaneously or in sequence (see figure). At the present state of development, the modules are the following:

- SMARTCOM (having the same name as that of the overall program) generates a graphical user interface (GUI) and controls the execution of the other modules. The GUI provides easy-to-use dialogues that help the user to specify data, define the problem, specify analysis options, visualize a structure, and visualize the results of the analysis of the structure. The results of the analysis can be displayed in both textual and graphical forms.
- SMARTPRE preprocesses data for mathematical modeling.
- SMARTMSH generates computational meshes for simple shapes.
- SMARTFEM is a finite-element-analysis code that models mechanical, thermal, and electric fields and is integrated directly with control algorithms.
- SMARTOPT contains optimization algorithms integrated with SMARTFEM.
- SMARTFUZ contains fuzzy modeling algorithms integrated with SMARTFEM.
- SMARTPRB implements probabilistic mathematical models and techniques.
- SMARTPOS postprocesses the results of an analysis for display.



This **Data-Flow Diagram shows** the relationships among some of the modules of SMARTCOM.

This work was done by Ming S. Hung of Expert System Applications, Inc., for **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Mechanics category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16810.

Magnetically Moved Trim Masses for Fine Position Control

Control would be achieved without spurious effects generated by propulsion systems.

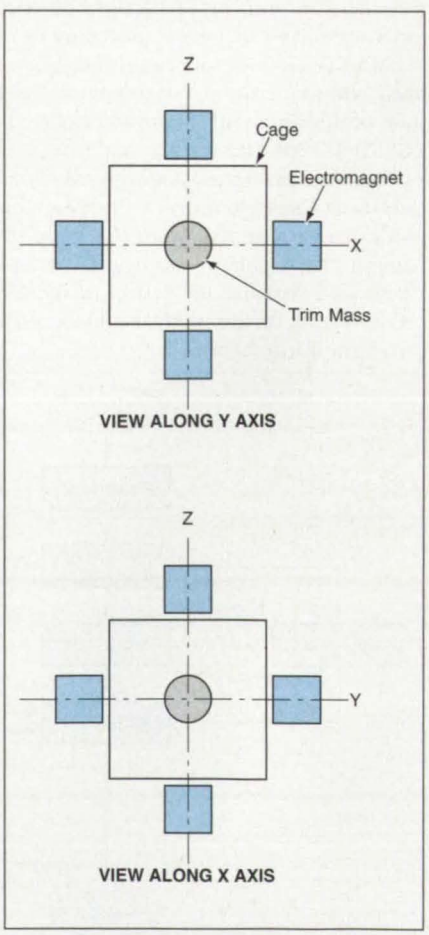
NASA's Jet Propulsion Laboratory, Pasadena, California

Systems of caged trim masses manipulated by magnetic fields have been proposed for effecting fine control of the positions and/or orientations of spacecraft. The systems were conceived for use during observations by spaceborne interferometers, the component instruments of which (1) are located on multiple spacecraft flying in formation and (2) are required to be kept aligned with each other within narrow position and orientation tolerances. The proposed systems would make it possible to avoid the spurious effects generated by the spacecraft propulsion systems that would otherwise have to be used for fine position control; the spurious effects would include vibrations, exhaust, and flashes of light, which would be detrimental to the interferometric observations. Terrestrial versions of the proposed systems might be useful for fine horizontal positioning of delicate scientific instruments.

Three caged trim masses would be needed for complete position and orientation control of a spacecraft in three dimensions. Each trim mass would be manipulated by three pairs of opposing electromagnets — one pair for each of three mutually orthogonal axes (see figure). During times when observations were not being performed (e.g., during use of the spacecraft thrusters), the electromagnets would be activated to reset the trim masses to, and hold them at, the central positions within their cages.

This work was done by James Kelley of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Mechanics category.*

NPO-20570



A Trim Mass Would Be Manipulated by six electromagnets located on the axes of a Cartesian coordinate system.

New Technique Improves Cirrus Cloud Characterization

Radiometric measurements at submillimeter-wavelength accurately characterize cirrus cloud properties.

NASA's Jet Propulsion Laboratory, Pasadena, California

A new technique for retrieving cirrus properties from radiometric measurements at submillimeter wavelengths has been developed. The technique can accurately measure the amount of ice present in cirrus clouds, determine the median crystal size, and constrain crystal shape. The retrieval algorithm improves upon prior algorithms by also retrieving middle and upper tropospheric water-vapor profiles in concert with cloud properties. This joint-analysis method corrects for retrieval errors introduced by water vapor in and near the cloud.

Submillimeter-wave cloud ice radiometry is a relatively new technique. In 1995, two theoretical papers were published describing the use of radiometry to characterize ice clouds. These studies indicated that cirrus clouds scatter the upwelling flux of submillimeter-wavelength radiation emitted by lower atmospheric water vapor back towards the Earth, thus reducing the upward flux of energy. (In the submillimeter-wave spectral region, ice particles primarily scatter radiation rather than emitting or absorbing it.) From space, this effect makes clouds look radiatively cold against the warm emissions of water vapor in the lower troposphere. The ability of cirrus ice to scatter radiation is primarily a function of the amount of ice and the distribution of crystal sizes. Scattering induced by changes in crystal size is distinguished from scattering induced by changes in the total ice content, termed the ice water path (IWP), by making measurements at widely spaced frequencies. Additionally, crystal shape can be constrained by determining the crystal height-to-width aspect ratio, which is derived from off-nadir measurements at orthogonal polarization angles. Key assumptions underlying the theoretical predictions were validated by a set of airborne measurements in 1996.

The new retrieval algorithm corrects for middle and upper tropospheric water vapor that degrades retrieval accuracy via two mechanisms. First, water vapor emits radiation, reducing the apparent fraction of the radiation scattered by an underlying cloud. Second, water

Experiment	IWP Decibel Error		D_{me} Decibel Error	
	Median	Root Mean Square	Median	Root Mean Square
CEPEX, Zenith Looking, 10 Channels	1.2	2.3	0.7	1.1
CEPEX, Slant Upward Looking, 10 Channels	1.1	2.2	0.6	1.0
CEPEX, Zenith Looking, 11 Channels	0.8	1.8	0.6	1.0
FIRE II, Nadir Looking, 10 Channels	1.2	2.1	1.0	1.6

Errors Associated With Retrieval of IWP and D_{me} are significantly reduced with the new retrieval technique.

vapor absorbs radiation, also reducing the apparent scattered fraction. Thus, there is a need for a retrieval technique that corrects for these water-vapor-induced screening effects. The new algorithm builds on previous work by simultaneously retrieving water-vapor profiles and cirrus properties.

A Bayesian algorithm is used to invert a mathematical model of the radiometric properties of both cloud ice and water vapor. The model is statistical in nature relying on a combination of an *in-situ* cirrus measurement database, assumptions about vertical cloud inhomogeneity, and estimates of cloud temperature. The *in-situ* cirrus database consists of measurements from four sets of field measurements including three sets taken over a tropical site (CEPEX) and one over a midlatitude, Midcontinent site (FIRE II). The assumptions about cloud inhomogeneity are based on the observed relationship between IWP and the median crystal diameter, D_{me}.

The accuracy of this method has been assessed in computational simulations using the complement of radiometric channel planned for a new airborne instrument, the submillimeter-wavelength cloud ice radiometer (SWCIR) currently being developed by JPL. The instrument will have the capability to make radiometric measurements at ten frequencies spanning from 183 to 643 GHz. The simulations have quantified the accuracy of expected cirrus retrievals and have also quantified improvements that could be expected with the addition of an 880-GHz channel. The table presents selected results from these simulations. These results illustrate the dramatic improvement in accuracy that is achievable with the new analysis technique.

This work was performed by Steven Walter of Caltech (now employed by Aerojet in Azusa, CA), and K. Franklin Evans and Aaron Evans at the University of Colorado for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*
NPO-21016

Maximum-Likelihood Template Matching

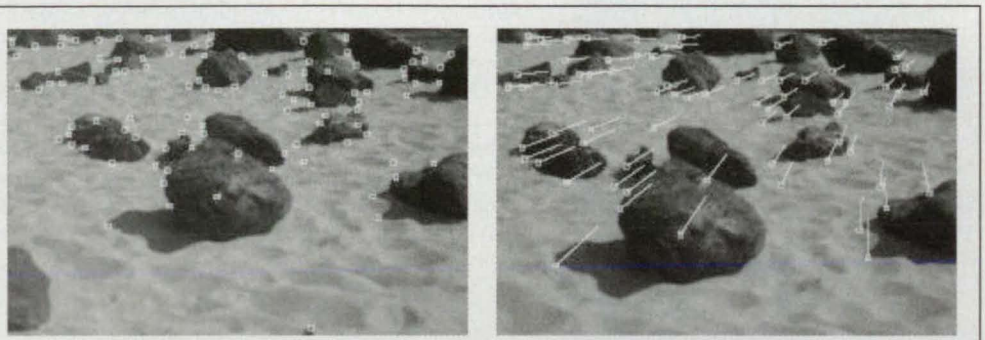
This algorithm features a robust measure of matching and an efficient search technique.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved algorithm for detecting gray-scale and binary templates in digitized images has been devised. The greatest difference between this algorithm and prior template-detecting algorithms stems from the measure used to determine the quality or degree of match between a template and given portion of an image. This measure is based on a maximum-likelihood formulation of the template-matching problem; this measure, and the matching performance obtained by use of it, are more robust than are those of prior template-matching algorithms, most of which utilize a sum-of-squared-differences measure. Other functions that the algorithm performs along with template matching include subpixel localization, estimation of uncertainty, and optimal selection of features. This algorithm is expected to be useful for detecting templates in digital images in a variety of applications, including recognition of objects, ranging by use of stereoscopic images, and tracking of moving objects or features. (For the purpose of tracking, features or objects recognized in an initial image could be used as templates for matching in subsequent images of the same scene.)

For the sake of computational simplicity, the present version of the algorithm involves two-dimensional edge and intensity templates, the pose space of which is restricted to translations in the image plane; however, it is possible, in principle, to extend the algorithm to more complex cases. The basic image-matching technique used in the algorithm utilizes a prior maximum-likelihood formulation of edge template matching that has been extended to include matching of gray-scale templates. In this formulation, one generates a function that assigns a likelihood to each of the possible positions of a template. In an application in which a single instance of the template appears in the image, (e.g., tracking or stereoscopy), one accepts the template position with the highest likelihood if the matching uncertainty is below a specified threshold. In other recognition applications, one accepts all template positions with likelihoods greater than some threshold value.

The search for the template position(s) is performed according a variant of a multiresolution technique that makes it unnecessary to consider all pos-



In an **Image of Rocky Terrain**, 100 7-by-7-pixel feature templates were selected as having the lowest uncertainty for tracking. Tracking was then performed in an image acquired after the camera had undergone forward motion. Seventy-two features survived to be tracked after pruning by use of uncertainty and probability-of-failure measures. No false positives remained among the tracked features.

sible template positions explicitly, yet makes it possible to find the best template position(s) in a discretized search space. In this technique, the space of model positions is divided into rectilinear cells and the cells are tested to determine which (if any) contain positions that satisfy a likelihood-based acceptance criterion. The cells that pass the test are divided into subcells, which are examined recursively, and the rest are pruned.

Inasmuch as the likelihood function measures the probability that each position is an instance of the template, error and uncertainty cause the likelihood-function peak that corresponds to that position to be spread over some volume of the pose space. Integration of the likelihood function under the peak yields an improved measure of the quality of the peak as a location of the template. Subpixel localization and estimation of uncertainty are performed by fitting the likelihood surface with a parameterized function at the locations of the peaks. In a stereoscopic or tracking application, the probability of failure to detect the correct position of the template is estimated in a procedure that includes a comparison of the integral of the likelihood under the most likely peak to the integral of the likelihood in the remainder of the pose space.

The foregoing techniques used for matching templates can also be adapted to the optimal selection of features for tracking. This involves estimation of the uncertainty of matching each possible feature with a region of the image in which it might lie. The features at the locations with the lowest uncertainty values are selected as the optimal features for tracking (see figure).

This work was done by Clark F. Olson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Information Sciences category.*

NPO-21026

Fast Algorithms and Circuits for Quantum Wavelet Transforms

These theoretical building blocks could be used to implement a variety of quantum algorithms.

NASA's Jet Propulsion Laboratory, Pasadena, California

Fast algorithms and the first complete and efficient circuits for implementing two quantum wavelet transforms have been developed in theory. The significance of this development within the overall development of quantum computing is the following: In principle, the algorithms and circuits constitute instructions for implementing the transforms by use of primitive quantum gates; the circuits in this case are analogous to circuit-diagram-level descriptions of classical electronic circuits that perform logic functions.

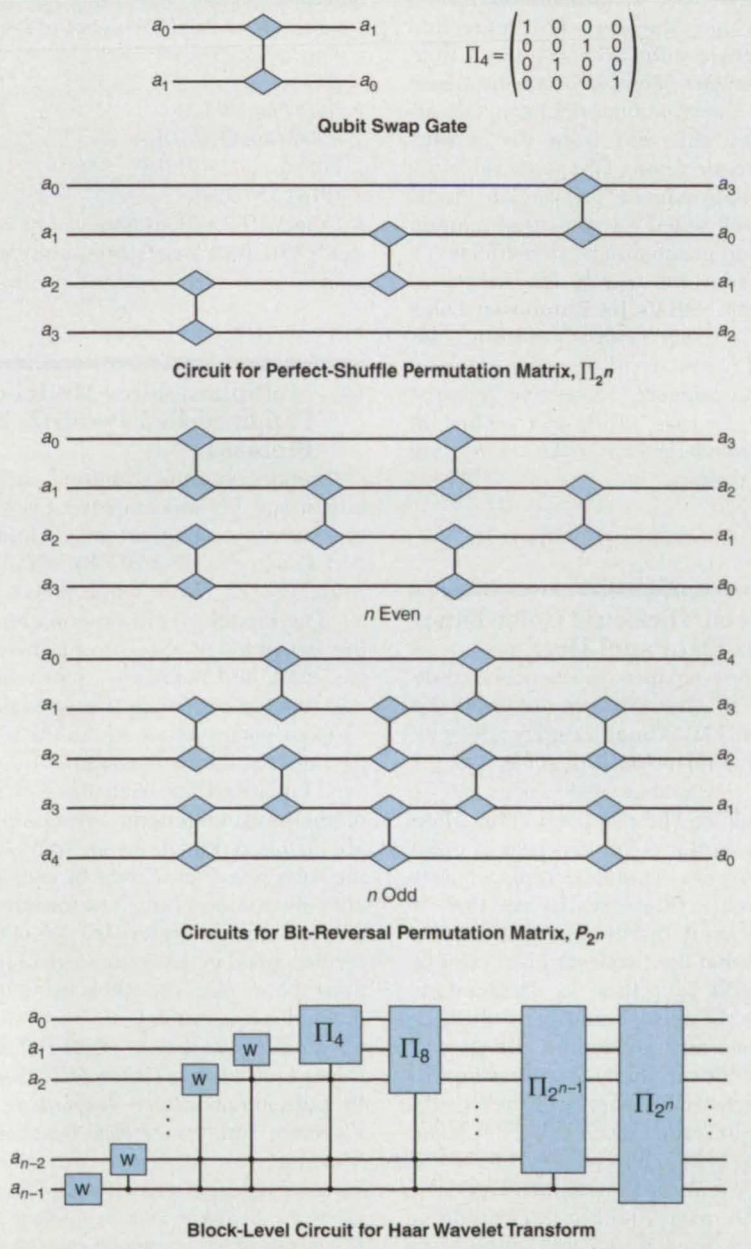
Quantum wavelet transforms are fundamental computational operations that can be incorporated into many different quantum algorithms. Such transforms could be useful for optical quantum compression of data and for quantum-enhanced image processing. They may even be useful for estimating quantum states. The two wavelet transforms of interest here are the quantum Haar and the quantum Daubechies $D^{(4)}$ transforms. The approach taken in the development of algorithms and circuits to implement these transforms involved factorization of the classical operators for these transforms into direct sums, direct products, and inner products of unitary matrices to enable efficient quantum implementation.

A particular class of unitary matrices — permutation matrices — play a pivotal role in this factorization. Permutation matrices arise not only in quantum wavelet transforms but also in quantum Fourier transforms and in many classical computations that involve unitary transforms for processing of signals and images. Computational operations that can be performed easily and inexpensively following a classical approach cannot always be performed this way following a quantum approach, and vice versa. The computational cost of permutation matrices is negligible in the classical approach because the matrices can be avoided explicitly, whereas in the quantum approach, permutation operations must be performed explicitly and hence the cost of these operations must be included in the full measure of the complexity and thus the cost of the affected quantum wavelet transforms.

One of the quantum circuits that was developed, denoted the "qubit swap gate," implements a fundamental permutation matrix denoted "Π_4." One can assemble qubit swap gates to implement other fundamental permutation matrices; namely, the perfect-shuffle matrix ($\Pi_2 n$) and the bit-reversal matrix ($P_2 n$). For quantum computing, the perfect-shuffle and bit-reversal matrices can be characterized directly in terms of their effects on the ordering of qubits. One can assemble building blocks of circuits for these and other matrices to implement the quantum Haar, Daubechies $D^{(4)}$, and wavelet transforms (see figure).

The present algorithms and circuits have been validated through extensive simulation. Prior to this development, it had been demonstrated that basic quantum gates can be implemented experimentally by use of nuclear magnetic resonance spectroscopy, cavity quantum electrodynamics, and ion traps. At the time of reporting the information for this article, no one had yet demonstrated that such gates can be integrated together into large-scale quantum circuits; however, efforts to do so were under way at NASA's Jet Propulsion Laboratory.

This work was done by Amir Fijany and Colin Williams of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Information Sciences category.*
NPO-20747



The **Qubit Swap Gate** implements the Π_4 permutation matrix. A circuit composed of multiple qubit swap gates can implement other fundamental permutation matrices.

Books & Reports

Study of Inertial and Gravitational Masses of a Boson

A report presents a theoretical study of the relationship between the inertial mass (m_i) and gravitational mass (m_g) of a self-interacting neutral scalar boson in a heat bath. The question of whether these masses differ arises in modern physics. In quantum field theory, the mass of a particle appears as a parameter that, as a result of interaction with fields, is changed to a renormalizable, physically reliable value (m_R). The interaction of a particle with fields also has a thermal character. Thus, a boson in a heat bath in a gravitational field gains an acceleration different from the gravitational acceleration. The study utilizes a simple approximate Lagrangian model that is well suited for analysis of temperature- and gravitation-related effects.

This work was done by Igor Kulikov of Caltech for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "Inertial and Gravitational Masses of Bosons at Finite Temperatures," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*

NPO-30325

Metal/Dielectric Color Filters for Flat Panel Displays

A report expands on the proposal described in "Low-Absorption Color Filters for Flat Panel Display Devices" (NPO-20435) *NASA Tech Briefs,* Vol. 23, No. 12 (December 1999), page 34. To recapitulate: The dye pixel color filters in a conventional liquid-crystal or other display device would be replaced with interference filters, which are less absorptive, and optics would be configured so that light reflected from the filters would be reused as illumination. The overall effect would be to increase brightness and efficiency. The present report adds specificity by proposing that the interference filters be of the type described in "Metal/Dielectric-Film Interference Color Filters" (NPO-20217), *NASA Tech Briefs,* Vol. 23, No. 2 (February 1999), page 70: Each filter would be made of three thin metal films interspersed with two thin dielectric films. In comparison with conventional multilayer all-dielectric filters, the proposed filters would contain fewer layers, and therefore could be fabricated more easily and at lower cost.

This work was done by Yu Wang of Caltech for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "Metal Film Interference Filter for Liquid Crystal Display Device," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-20479, volume and number of this NASA Tech Briefs *issue, and the page number.*

Multiphase-Flow Model of Fluidized-Bed Pyrolysis of Biomass

A report presents additional information about the subject matter of "Model of Pyrolysis of Biomass in a Fluidized-Bed Reactor" (NPO-20708) *NASA Tech Briefs,* Vol. 25, No. 6 (June 2001), page 59. The model is built on equations for the dynamics of three components — gas, sand, and biomass — partly by taking suitable ensemble averages of the coupled conservation equations for the gas, and for the biomass and sand particles. Equations for exchanges of mass, momentum, and energy between phases are included. Equations for transport of the solid phase are closed by use of separate distribution functions for sand and biomass particles. Interparticle collisions are described in the framework of the kinetic theory of dense gases, using inelastic-rigid-sphere models.

This work was done by Josette Bellan and Danny Lathouwers of Caltech for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "Multiphase Flow Equations for Modeling Tar Production from Biomass Particle Pyrolysis in a Fluidized Bed Reactor," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*

NPO-20789

Vision-Only Operator Interface for a Robotic Manipulator

Images of the actual and commanded robot poses are displayed along with warnings.

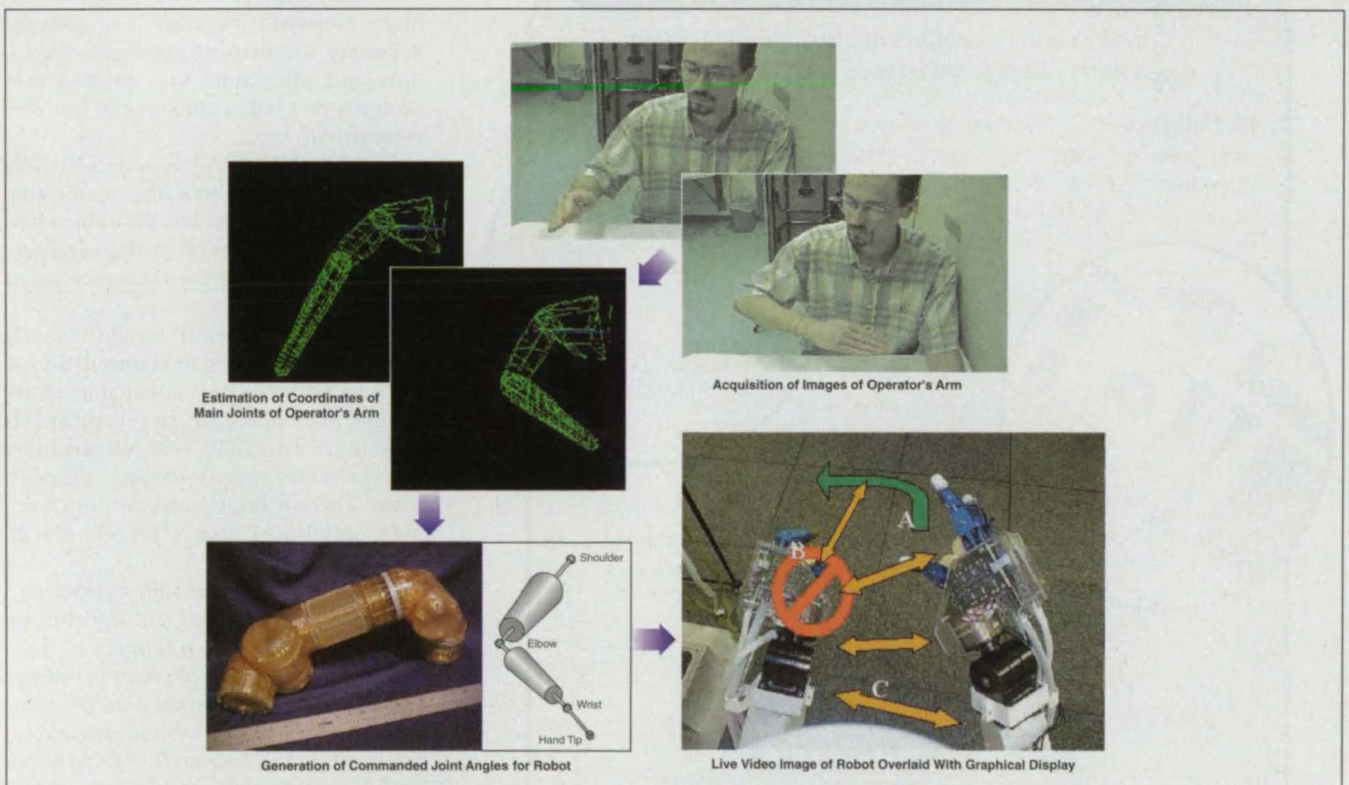
NASA's Jet Propulsion Laboratory, Pasadena, California

A system of electronic hardware and software has been developed as an experimental prototype of a visual interface between a human operator and a possibly remote one-arm anthropomorphic robotic manipulator. The system is denoted, more specifically, as a vision-only operator interface to emphasize that unlike some other operator interfaces, it does not include joysticks, force-feedback devices, or other mechanical devices that could encumber the operator. The operator commands the robot by moving one of his or her arms; the operator receives feedback in the form of a live video image of the work space of the robot overlaid with a graphical model of the robot plus icons that warn of robot poses that should be avoided.

The figure is a simplified schematic depiction of the flow of data within the system and the sequence of actions performed by the system. The flow of data begins with acquisition of images of the operator's arms, by use of four video cameras that surround the operator. To facilitate tracking, the operator's space is darkened and the main joints (shoulder, elbow, and wrist) of the operator's arm are marked with small light bulbs. The image data from the video cameras are processed into three-dimensional Cartesian coordinates of the main joints at a video frame rate of 60 Hz, with an accuracy of 10 mm.

The coordinates of the main joints of the operator's arm are converted to commanded angles for joints of the robot arm. These commanded angles are used to construct the graphical model of the robot to be overlaid on the live video image of the robot. The model data are analyzed to detect self-collisions, which are defined here as situations in which two links of the manipulator come too close to each other. The links in danger of colliding with each other can be highlighted in the graphical display to help the operator avoid self-collisions; alternatively, lines indicating distances of closest approach can be drawn in the display.

In this system, the commanded joint angles are generated by use of the configuration-control formalism, which has been described in a number of prior *NASA Tech Briefs* articles. The configuration-control formalism can resolve mathematical singularities associated with kinematic redundancies, but adds algorithmic singularities to robot poses that the operator would not easily recognize as being singular. Therefore, in the graphical display, the work space in the vicinity of the



Images of the Operator's Arm are processed into commanded robot-joint angles and into a graphical display of the commanded robot pose plus warning icons overlaid on a video image of the robot.

wrist of the robot arm is discretized into cubes, and each such cube is marked in red to indicate that a quantitative measure of the risk of a kinematic or algorithmic singularity at the center of that cube exceeds a specified threshold. The quantitative measure is the determinant of $J_A J_A^T$, where J_A is the augmented Jacobian determinant of the system, computed for the current orientation and the current manipulator arm angle (defined as the angle between shoulder/elbow/wrist plane and the vertical plane that contains both the wrist and the base of the robot).

This work was done by Paolo Fiorini, Eugene Chalfant, Pietro Perona, Enrico DiBernardo, and Yuichi Tsumaki of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*
NPO-20912

Compact, Stiff, Lightweight, Quick-Release Clamp

This clamp offers several advantages over a prior toggle-action clamp.

Lyndon B. Johnson Space Center, Houston, Texas

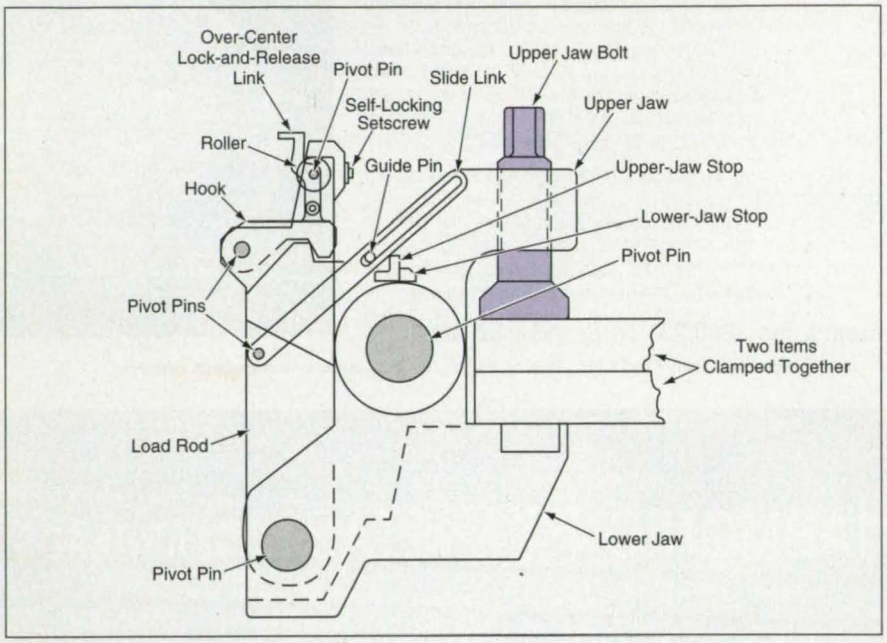
The term "COSMOWRAP" denotes a compact, stiff, remotely actuatable, lightweight, quick-release clamp that could be substituted for the larger, heavier, and more-difficult-to-use toggle-action clamp now used in the space shuttle orbiter docking system (ODS) to perform contingency separations. In comparison with prior hand-operated devices designed for the same purpose, the COSMOWRAP is smaller and lighter in weight, yet offers greater capabilities. The COSMOWRAP (see figure) contains no spring and requires no pre-flight calibration or maintenance. The COSMOWRAP is expected to perform well, not only in the space-shuttle application for which it was originally designed, but also in terrestrial applications. Because the design of the COSMOWRAP reduces the force needed for installation or removal and provides for release by the action of one hand, the replacement of the ODS toggle-action clamp by the COSMOWRAP can be expected to contribute to crew safety in the United States space program and on the International Space Station.

The toggle action clamp, an adjunct to the ODS, carries a high load and is remotely manually released by use of a tether. As its name implies, it includes a toggle-action mechanism. The mechanism includes an actuating lever. Unfortunately, because of time limits, the design of the toggle-action clamp was not optimized before the clamp was produced. As a result, the toggle-action clamp is heavy as well as very large and cumbersome — a circumstance worsened by need for two such clamps on each spaceflight. The combined assembly length of the toggle-action clamps is >32 in. (>81.3 cm) and each toggle-action clamp weighs 22 lb. (a mass of 10 kg). In addition, the operation of the toggle-action clamp is affected by friction in its joints. Because the force needed to operate the toggle-action clamp is greater than that originally expected, a winch tool must be used to perform a release maneuver when the clamp load is high. Moreover, because it is typically necessary to perform pre-flight calibration and checkout, the toggle-action clamp is not only cumbersome but also expensive to use.

The COSMOWRAP is a user-friendly and cost-efficient alternative to the toggle-action clamp and has desirable characteristics not observed in the toggle-action clamp. Among these characteristics are the following:

- The clamping load is significantly higher at release than at installation.
- The COSMOWRAP is capable of remote manual release. Its release load is no more than 25 lb. (111 N) [the value required for space missions], although the load on the clamp portion of the COSMOWRAP can approach 104 lb. (44 kN).
- The clamp can open fully at release to enable separation of previously clamped interfacial components.

Two especially notable features of the COSMOWRAP design are a double-slant interface and an over-center lock-and-release rolling mechanism that provide operational advantages over the toggle-action clamp and enable quick release. Whereas friction in the joints resists oper-



The **COSMOWRAP** serves the same purpose as does a toggle-action clamp, but is smaller, stiffer, lighter in weight, more easily operable, and more capable.

ation of the handle in the toggle-action clamp, the COSMOWRAP design utilizes the friction in the joints in its main load path to reduce the release load. At release, the double-slant interface configuration of the COSMOWRAP enables complete and quick severance of load paths; as a consequence, the components of the COSMOWRAP can be made short and compact, thus contributing to an optimized design characterized by minimum weight and maximum stiffness. Other benefits of the COSMOWRAP design are the following:

- The over-center lock-and-release rolling mechanism enables the COSMOWRAP to lock itself under load.
- The roller mechanism in the COSMOWRAP is not only less adversely affected by friction than is the corresponding mechanism in the toggle-action clamp; in addition, the COSMOWRAP mechanism includes a setscrew that enables the precise adjustment of the release load.
- A slide link makes one-hand operation possible.

Although high-strength-steel components are included in the COSMOWRAP, it could be possible to make some components from aluminum, depending on the magnitude of the load anticipated for the intended application. The required slope of the slant interfaces depends on the finish of interface-bearing surfaces. Once a surface finish and coating have been specified and the corresponding ranges of friction are known, the required slope can be easily determined and verified by simple tests.

Ease of use, a weight-and-space-saving design, and one-handed operation make the COSMOWRAP an attractive addition to the U.S. space program. The COSMOWRAP can be used, for example, to assemble and disassemble a wide variety of highly loaded gasket joints; thus, it can be expected to be suitable for a variety of applications in hazardous environments, not only in outer space but also on Earth (for example, in the repair and construction of pipelines, firefighting, and demolition). The COSMOWRAP can also be used as a quick-release C clamp, jig, or fixture in place of many other lever- and/or toggle-actuated mechanisms.

This work was done by Ted W. Tsai of **Johnson Space Center.**

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22722.

Software for Geometric Calibration of Video Cameras

NASA's Jet Propulsion Laboratory, Pasadena, California

A software library and set of programs largely automate the geometric calibration of video cameras. Developed especially for robotic vision systems, this software generates the information needed to determine the three-dimensional (3D) positions of objects that appear in two-dimensional (2D) video images. Typically, the software can perform 2D-to-3D mappings with precision of 0.1 to 0.3 pixels. The software enables the creation, manipulation, and application of geometric models of camera lenses. The models are constructed semiautomatically from images of known calibration targets, and these models can be applied automatically to live images, thereby enabling robots to generate the position information needed for such robotic operations as manipulation of objects, mapping, and navigation. The software supports three main types of models: (1) linear (ordinarily suitable for fields of view narrower than about 30°), (2) radial lens distortion (typically suitable for fields of view ranging from 15° to 110° wide), and (3) fisheye lens distortion (typically suitable for fields of view wider than 90°). Camera models generated by this software have enabled the development of real-time, vision-based control systems on a variety of advanced civilian and military robots.

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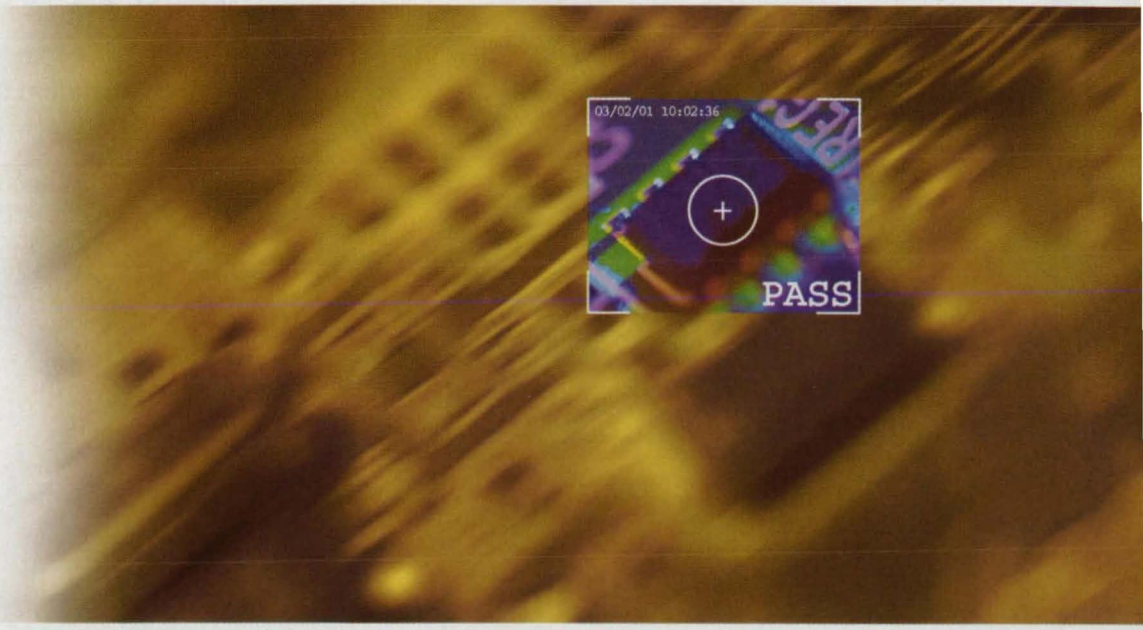

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The algorithms and software were developed by Don Gennery, Todd Litwin, Yalin Xiong, Mark Maimone, and Larry Matthies of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*

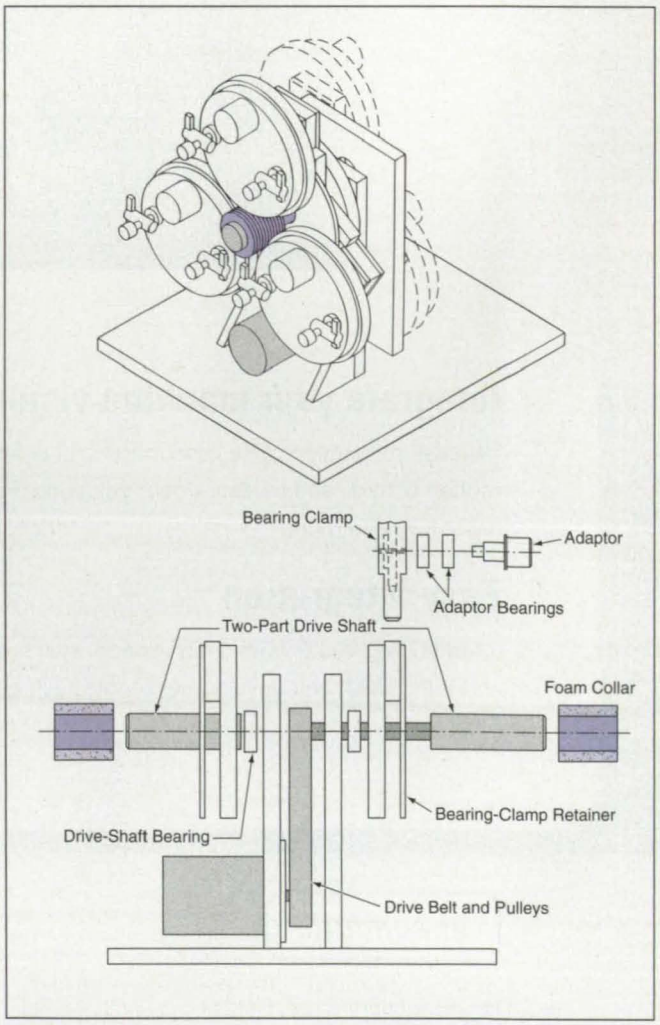
This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-21077.

Motor Drive for Multiple Horizontally Rotating Bioreactors

Bioreactors can be installed and removed easily.

Lyndon B. Johnson Space Center, Houston, Texas

The figure depicts a mechanism that is capable of simultaneously rotating as many as six disposable bioreactor chambers about horizontal axes. The particular bioreactor chambers for which this mechanism is designed are high-aspect-ratio vessels (HARVs), which are round cylindrical vessels developed by NASA.



This **Drive Mechanism** rotates as many as six bioreactor chambers simultaneously. A chamber can be removed during operation, without disturbing the rotation of the other chambers.

The source of motion is a 24-Vdc geared electric motor with an output shaft speed of 300 rpm in the absence of a load. By means of a toothed drive belt and pulleys, rotation is coupled from the geared-motor output shaft to a drive shaft, which is located centrally relative to the axes of rotation of the bioreactor chambers. The sizes of the pulleys and gear belt can be changed to obtain different speeds of rotation.

Each bioreactor chamber is mounted on an adaptor equipped with bearings that allow free rotation about a horizontal axis. The bearings, in turn, are clamped onto a stationary retainer. A foam collar on each end of the drive shaft makes contact with the outside diameters of the bioreactor chambers, acting as a frictional coupling to transfer rotation of the drive shaft to the bioreactor chambers. The compressibility of the collar accommodates variations in the diameters of the chambers. By loosening the bearing clamp of any given reactor chamber, one can remove that chamber without stopping the rotation of the other chambers.

This work was done by Eric D. Johnston and Mitchell Litt of the University of Pennsylvania for **Johnson Space Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Machinery/Automation category.*
MSC-22860

Tip Fences for Reduction of Lift-Generated Airframe Noise

These simple, easily retrofitted devices reduce drag as well as noise.

Ames Research Center, Moffett Field, California

Tip fences have been invented to reduce the noise generated in the airflows about the high-lift systems (the flaps and slats) of airplane wings. Tip fences also afford an important secondary benefit by increasing lift-to-drag ratios.

Typical modes of operation of the flaps and slats of an airplane wing are the following: In preparation for takeoff, the flaps are partly extended, and the slats are fully extended to provide a clean airflow over the main element of the wing. Shortly after takeoff, the slats are retracted to increase the lift-to-drag ratio during climbout. During landing, the slats and flaps are fully extended, and significant aerodynamic noise is generated at their tips. Tip fences can reduce the noise generated during takeoff and climbout, but more importantly during approach and landing.

Tip fences are so named because they are fencelike barriers and are mounted at or near some or all of the inboard and outboard tips of the flaps and slats (see Figure 1). These mounting locations are chosen because they are as close as possible to the aerodynamic-surface discontinuities where

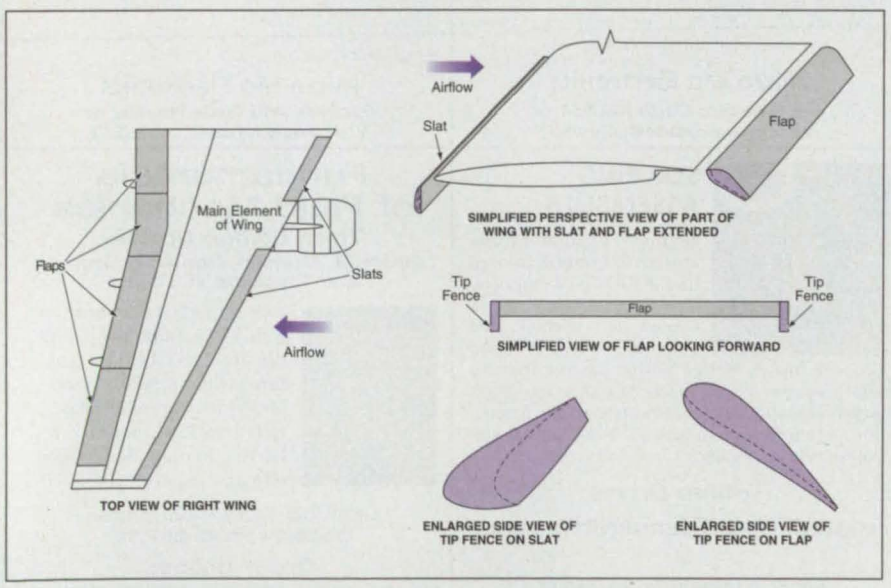


Figure 1. **Tip Fences** can readily be added to flaps and slats to reduce noise and drag.

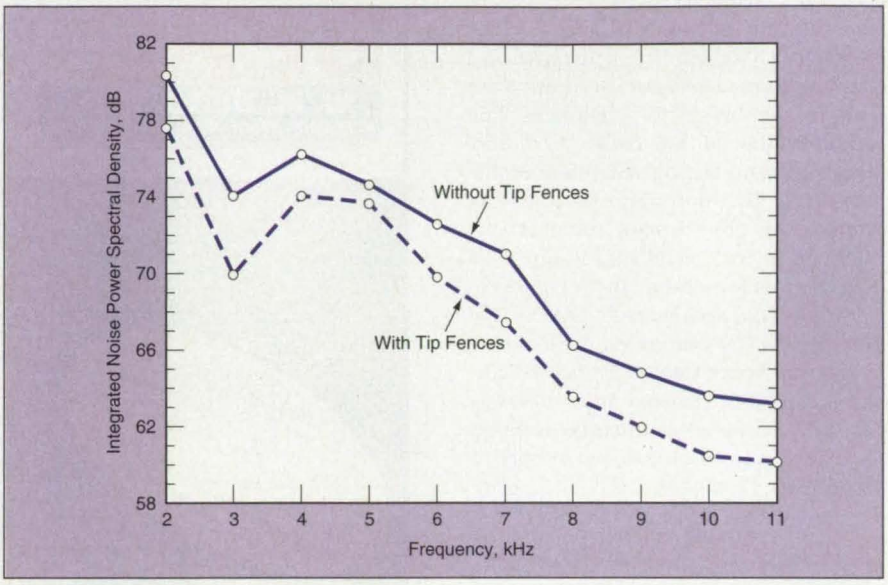


Figure 2. **Less Noise Was Generated** by the airflow over a wing equipped with flap tip fences than by the airflow over same wing without flap tip fences under otherwise identical test conditions.

vortices associated with noise form when flaps and slats are extended. Tip fences can be made of any suitable rigid material (e.g., metal or composites) and can be attached to the tips of flaps and slats by riveting, welding, bolting, or other conventional means. They can be easily and inexpensively retrofitted to most pre-existing airplanes, with minimal design changes.

A tip fence can be formed from a flat plate, or, if desired, it can be fabricated as a more complex, aerodynamically contoured body. In a typical application, the tip fences would extend below the lower surface of a slat or flap, as depicted on the right side of Figure 1. However, other combinations of tip and fence configurations are also possible.

In a demonstration of the benefits of tip fences, two different versions of a wing with flap extended were tested in a wind tunnel and in flight on a Lanceair IV airplane. In one version, the flap was equipped with tip fences; in the other version, it was not. The flight data is shown in Figure 2, demonstrating that the tip fences caused less noise to be generated over a broad range of frequencies. The wind-tunnel data showed that tip fences can also reduce the profile or viscous drag significantly.

This work was done by James C. Ross and Bruce L. Storms of **Ames Research Center.** *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com/tsp*** *under the Mechanics category.*

This invention has been patented by NASA (U.S. Patent No. 5,738,298). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14009.

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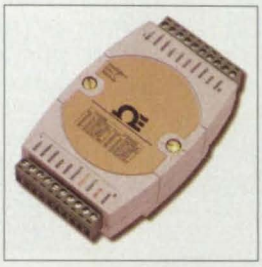
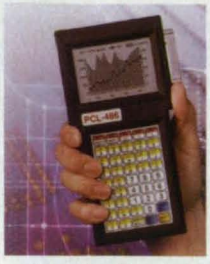


Vibration Analyzer

The portable ZonicBook™ vibration analyzer from IOtech, Cleveland, OH, is available in 4-, 8-, or 16-channel configurations. The device accepts ICP® accelerometer and microphone inputs directly, and simultaneously samples all channels at 51.2 kHz with a separate Sigma Delta converter for each input channel. Analysis capabilities include FFT analysis, integration/differentiation, averaging, octave analysis, and standard AC and DC voltage. The unit uses Windows-based eZ-Analyst™ software and a notebook computer to acquire continuous, gap-free data into the PC's memory and hard drive. **For Free Info Circle No. 733 or Enter No. 733 at www.nasatech.com/rs**

Handheld Computer

The PCL-486 handheld computer from Two Technologies, Horsham, PA, is based on the ROM-DOS® 6.22 operating system and features a 192 x 128 pixel LCD capable of displaying text and graphics. The standard memory configuration includes 8 MB of RAM and 2 MB of FLASH. The optional PC Card slot provides additional storage capacity. Other features include a serial port that can be configured for RS-232, RS-422, or RS-485. Multiple keypad layouts are available with standard or custom graphics. **For Free Info Circle No. 734 or Enter No. 734 at www.nasatech.com/rs**



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X ❑ Communications
O ❑ Automotive
T ❑ Transportation
M ❑ Materials/Chemicals
P ❑ Power/Energy
B ❑ Bio/Medical
J ❑ Consumer Product Manufacturing
Q ❑ Industrial Machinery & Equip.
A ❑ Aerospace
G ❑ Government
D ❑ Defense
R ❑ Research Lab
U ❑ University
Z ❑ Other *(specify)*: _____

3 **Your engineering responsibility is:** *(check one)*

A ❑ Manage Engineering Department
B ❑ Manage a Project Team
C ❑ Manage a Project
D ❑ Member of a Project Team
E ❑ Other *(specify)* _____

4 **Your job functions are:** *(please check all that apply)*

10 ❑ Design & Development Engineering (Inc. applied R&D)
12 ❑ Testing & Quality Control
13 ❑ Manufacturing & Production
14 ❑ Engineering Management
16 ❑ General & Corporate Management
17 ❑ Basic R&D
15 ❑ Other (specify)

Write in the number of your principal job function _____

5 **a. In which of the following categories do you recommend, specify, or authorize the purchase of products?** *(check all that apply)*

01 ❑ Electronics
02 ❑ Photonics
03 ❑ Computers/Peripherals
04 ❑ Software
05 ❑ Mechanical Components
06 ❑ Materials
07 ❑ None of the above

5 **b. Products you recommend, specify, or authorize for purchase:** *(check all that apply)*

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33 ❑ Connectors/interconnections/ packaging/ enclosures
02 ❑ Board-level products
18 ❑ Sensors/transducers/detectors
16 ❑ Data acquisition
19 ❑ Test & measurement instruments
34 ❑ Power supplies & batteries
35 ❑ PCs & laptops
06 ❑ Workstations
36 ❑ EDA/CAE software
37 ❑ CAD/CAM software
17 ❑ Imaging/video/cameras
38 ❑ Lasers & laser systems
39 ❑ Optics/optical components
40 ❑ Fiber optics
41 ❑ Optical design software
20 ❑ Motion control/positioning equipment
30 ❑ Fluid power and fluid handling devices
31 ❑ Power transmission/motors & drives
42 ❑ Rapid prototyping and tooling
13 ❑ Metals
28 ❑ Plastics & ceramics
27 ❑ Composites
43 ❑ Coatings
80 ❑ None of the above

6 **How many engineers and scientists work at this address?** *(check one)*

A ❑ 1
B ❑ 2-5
C ❑ 6-19
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17 ❑ None of the above

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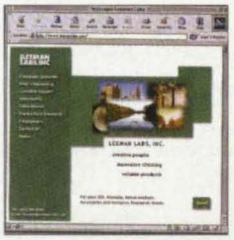
A new Web site from Kent Elastomer Products, Kent, OH, features an on-line order capability for natural rubber latex, PVC and TPE tubing, multilumen, solid cord and profiles, FREEBAND™ Latex Free and natural rubber latex tourniquets, and dip molded products. Each product selection offers information on specifications, and outlines the company's production capabilities. **www.kentelastomer.com**

Elemental Analysis



Leeman Labs, Hudson, NH, has created a Web site featuring information on products including ICP spectrometers, metal and metal alloy analyzers, inorganic standards for elemental analysis, cold vapor atomic absorption mercury analyzers, and sample preparation equipment for mercury analysis. A site map contains information about the company, special promotions, and exhibition and seminar schedules. **www.leemanlabs.com**

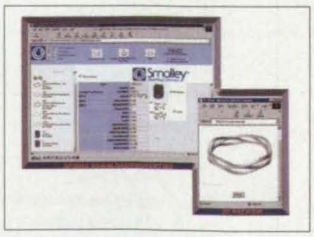
Fasteners

PEM® Fastening Systems, Danboro, PA, has added an on-line "PEMSelect Dynamic Product Locator" to its Web site, enabling design engineers to search the entire database of PEM® fasteners and then download specifications, drawings, and literature. The tools provide users with a choice of part number search, part description search, interactive search, and photo index search methods. **www.pemnet.com**

Injection Molding

Twinshot Technologies, Rifton, NY, offers a Web site describing the company's co-injection process using a modified standard injection molding machine. The site features explanations of the technology and includes a savings calculator, enabling users to alculate cost using the Twinshot system. **www.twinshot.com**

CAD Models



Smalley Steel Ring, Wheeling, IL, offers on its Web site downloadable CAD models available in 91 formats. The site allows users to view 3D and isometric picture previews, and search for parts, which can be downloaded by sending the part model to their own e-mail address. Users can also request free catalogs, software, engineering assistance, samples, and quotes. **www.smalley.com**

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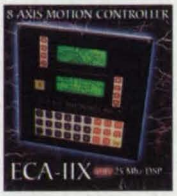

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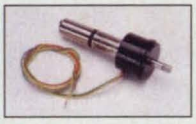

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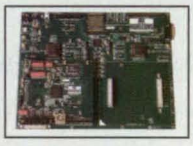

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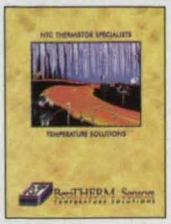

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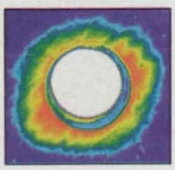

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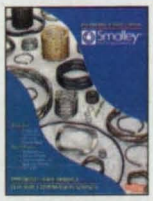

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