



NASA
TECHNOLOGY APPLICATIONS TEAM
APPLICATIONS OF AEROSPACE TECHNOLOGY

QUARTERLY REPORT

April 1993 - June 1993

for

National Aeronautics and Space Administration
Office of Advanced Concepts and Technology
Washington, DC 20546



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April 1993 - June 1993

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INTRODUCTION

This report covers the activities of the Research Triangle Institute (RTI) Technology Applications Team for the period 1 April 1993 through 30 June 1993. The work reported herein was supported by the National Aeronautics and Space Administration (NASA), Contract No. NASW-4367. Mr. Len Ault, NASA Headquarters, was the technical monitor. The work was performed in the RTI Center for Technology Applications under the direction of Dr. D. J. Rouse. Other participants in the program were Ms. Molly Dix, Mr. Dean Hering, Mr. Gary Hughes, Mr. Stephen Lehrman, Mr. Stephen Mangum, Mr. Daniel Winfield, Mr. Michael Hackett, Ms. Denise Maynard and Ms. Nancy Court. RTI consultants participating during the reporting period were Dr. Catherine Canada, Mr. Harry Watters and Mr. Jim Harrell.

Highlights of the RTI Applications Team activities over the past quarter are presented in Section 1.0. The Team's progress in fulfilling the requirements of the contract is summarized in Section 2.0. In addition to our market-driven approach to applications project development, RTI has placed increased effort on activities to commercialize technologies developed at NASA Centers. These Technology Commercialization efforts are summarized in Section 3.0. New problem statements prepared by the Team in the reporting period are presented in Section 4.0. The Team's transfer activities for ongoing projects with the NASA Centers are presented in Section 5.0. Section 6.0 summarizes the status of four add-on tasks. Travel for the reporting period is described in Section 7.0. The RTI Team staff and consultants and their project responsibilities are listed in Appendix A.

The authors gratefully acknowledge the contributions of many individuals to the RTI Technology Applications Team program. The time and effort contributed by managers, engineers, and scientists throughout NASA were essential to program success. Most important to the program has been a productive working relationship with the NASA Field Center Technology Utilization (TU) Offices. The RTI Team continues to strive for improved effectiveness as a resource to these offices. Industry managers, technical staff, medical researchers, and clinicians have been cooperative and open in their participation. The RTI Team looks forward to continuing expansion of its interaction with U.S. industry to facilitate the transfer of aerospace technology to the private sector.

1.0 HIGHLIGHTS

Projects

- RTI organized and chaired the May 19-20, 1993 **NCI-NASA Workshop on Digital Mammography Technologies** in Bethesda, MD. The meeting was a huge success with over 90 persons attending, including 28 medical imaging industry representatives. The National Electrical Manufacturers Association assisted us by coordinating industry invitations. A number of participants have contacted us concerning ideas for R&D partnerships as a result.
- RTI also provided a summary of the NCI-NASA collaboration and the NCI-NASA Workshop to Dr. Frank Sulzman of NASA HQ Life Sciences. Dr. Sulzman and Dr. Shtern (NCI) presented this collaboration to the **NASA-NIH Advisory Committee** on June 29-30; the Committee praised the collaboration, saying, "We should be doing more things like this."
- The RTI Team organized and participated in **meetings with potential commercialization partners** at Ames Research Center to demonstrate and discuss the **Ames Modular Programmable Sensor Conditioning System**. Two physiological monitoring companies met separately with the Ames researchers and will respond to Ames with their view of areas for possible collaboration.
- RTI participated in a **meeting at IVAC Corporation to discuss the application of the Stennis Space Center predictive response algorithm to IVAC's electronic thermometer**. IVAC was identified as a potential partner by way of an RTI-developed Technology Opportunity Announcement. The meeting resulted in a phase I project plan to develop a proof-of-concept product.
- The **National Center for Manufacturing Sciences (NCMS)** task group on printed circuit board cleanliness voted to **approve the Langley Research Center proposal to characterize the Optically Stimulated Electron Emission (OSEE) inspection process**. This project is the result of ongoing RTI discussions with NCMS to identify NASA solutions to industry-wide problems. A patent application has been filed by Langley on using OSEE as a quality inspection monitor.
- **Red Pepper Software is securing a software license from the Kennedy Space Center for the Ground Processing Scheduling System (GPSS)**. This artificial intelligence based software was developed to handle the massive scheduling task for preparing shuttle orbiters for their next missions. Red Pepper also reports that they are close to an agreement to provide the software and services to one of the attendee companies from the December, 1992 Technology Briefing organized by RTI.

- RTI completed and mailed the **Opportunity Announcement for the commercialization workshop for the Powder Prepreg Curtain Technology**. The brochure was printed by Langley Research Center and mailed by RTI. Two companies, Electrostatic Technologies and Polymer Composites, Inc., expressed interest in the technology.
- The RTI Team prepared a **Technology Opportunity Announcement (Appendix B) for the Virtual Visual Environment Display (VIVED)** from Johnson Space Center. The TOA was sent to JSC for use at a conference June 26 and mailed to a list of target companies. We also mailed the TOA to the six RTTCs for their assistance in locating a commercial partner.
- RTI developed a **Technology Opportunity Announcement (Appendix B) for the Fiber Optic Probe for Cataract Detection** from Lewis Research Center. We are obtaining NASA review and developing a targeted mailing list. The TOA will be distributed in July.
- The RTI Team conducted two telephone conference calls between **Laureate Learning Systems** and the JSC Software Technology Branch to determine the **Early Language Intervention System (ELIS)** project status and to facilitate communication between the two groups. At RTI's suggestion, Mr. Bob Way of JSC visited Laureate to work with them on the graphics interface.
- RTI identified **potential funding from the EPA Risk Reduction Engineering Laboratory** for the Lewis Research Center's **unique ion exchange material**. RTI assisted LeRC in identifying markets and potential commercial partners.
- RTI met with the **Center for Composite Materials (CCM), University of Delaware**, on May 3, 1993. The CCM is serving as a source for a series of problem statements dealing with priority problems faced by the advanced materials industry. Responses to the first problem statement which addresses needs in joining technologies, were given to the Center for Composite Materials for technical review.

Outreach

- Doris Rouse chaired a session on **Technology Transfer at the 30th Space Congress** and presented a paper entitled "Dividends from Space: How NASA Technology has Provided a Competitive Advantage for Industry." More than 100 representatives from NASA, industry and the public attended the session.
- RTI attended the **annual meeting of the Air & Waste Management Association** in Denver. RTI made contacts for future commercialization opportunities and for sources of environmentally related problem statements. RTI also made a brief presentation to the hazardous waste committee.

- RTI met with the Executive Director of the **Hazardous Materials Control Research Institute (HMCRI)**, Greenbelt, MD, on May 4, 1993. HMCRI is an excellent connection to the industrial hazardous waste treatment community. **RTI is providing a series of articles for the HMCRI monthly magazine, *Focus*, to cover technology transfer with the federal laboratories.** In addition, RTI was invited to organize a presentation/workshop as a part of their annual Superfund Conference in November.
- RTI developed two ***Spinoff!*** sheets (**Appendix B**) during the third quarter. The first describes Goddard Space Flight Center's **Capaciflector spinoff** success with transfer to **Computer Application Systems, Inc.** The second sheet was developed at the request of Marshall Space Flight Center. This sheet describes the **Ocular Screening System** developed and commercialized by MSFC and **Vision Research Corporation.** The sheets are used by the Applications Team, the Field Centers, and the companies to publicize NASA spinoff successes.
- RTI met with Mr. Rob Busacca of **Pepsi Cola International** to discuss the **problem statements being developed with the National Soft Drink Manufacturers Association.** Two industry-wide problems were selected for development: (1) rapid measurement of carbon dioxide purity and (2) water treatment for post-mix equipment.
- RTI discussed the NASA Technology Transfer Program with Mr. Nick Cerwin of the **American Iron and Steel Institute** and with Dr. Robert Steele of **Strategies Unlimited**, representing the **Optoelectronics Industry Development Association.**
- The RTI Team is working with the **Air Conditioning and Refrigeration Institute (ARI)** on a problem statement concerning frost elimination and prevention on air-conditioning and refrigeration evaporator coils. A draft of the problem statement has been reviewed with ARI and sent to seven industry experts for their review and comment.
- RTI attended the **American Society of Mechanical Engineers (ASME) National Laboratories Technology Transfer Committee (NLTTTC) Meeting** in Washington, DC. The NLTTTC consists of Deputy Directors of eleven DoE National Labs and the Deputy Director of NIST. The purpose of the meeting was to discuss the future role of the committee and the expansion of the committee to include NASA and EPA. ASME and NLTTTC agreed for NASA to author a technology transfer article in the August, 1993 issue of ASME News. RTI arranged for Dr. Chris Johnson of Lewis Research Center to author the article on Lewis' Computational Materials Laboratory.
- The RTI Team worked with the **White Sands Test Facility** to publicize their assistance to industry to improve the safety of materials, components and systems used in oxygen enriched service. Mr. Lehrman contacted ***NASA Tech Briefs*** regarding their interest in featuring an article on the facility.

- RTI met with the **University of Cincinnati Space Engineering Research Center**. Several technologies, including an infrared technique for joining materials, appear to be candidates for commercialization.
- The RTI TAT had several discussions with **McDonnell Douglas Aircraft Corporation** covering a number of technical issues. An area of common interest is the transfer of technologies from NASA to the aerospace industry.
- RTI interviewed a number of **Environmental Protection Agency** and industry representatives to identify the most critical technology challenges facing the environmental industry. Two environmental technology areas were subsequently selected: indoor air quality and hazardous waste treatment.
- RTI met with the **National Environmental Technology Applications Corporation**. This organization has had a cooperative agreement with the U.S. Environmental Protection Agency for the past five years. Discussions focused on the needs for technology transfer in the environmental management industry.
- RTI attended the **Federal Laboratory Consortium** semi-annual meeting in Pittsburgh, April 19-21.
- RTI met with Stephen Gomes and Paul Masson from **The American Technology Initiative (Amtech)** on two separate occasions to explore approaches for closer RTI/AMTECH collaboration in support of NASA's technology transfer objectives.

Support to HQ and Centers

- The RTI Technology Application Team met with the **Antenna and Microwave Research Branch at Langley Research Center**. Technology transfer concepts were discussed to assist this branch with documenting past activity and to plan for more effective, proactive technology transfer processes in the future.
- RTI gave an overview of the Technology Applications Team technology transfer activities to the **NASA Operations Intercenter Work Group (IOWG)** at Ames Research Center. The Team participated in discussions concerning effective mechanisms for the IOWG to pursue technology commercialization. In follow-up, Mel Montemerlo, NASA HQ Code C, and Peter Friedland, NASA Ames, have asked RTI to assist in identifying technology commercialization opportunities in the area of intelligent data analysis.
- RTI and representatives from **IC²** and the **Midcontinent RTTC** met with the **JSC New Initiatives Office** staff and Houston industry representatives to develop a coordinated approach for commercialization of NASA JSC technology.

- RTI made a presentation on the development of dual-use technology transfer projects to the **"Primary Targeted to Secondary Targeted Technology Transfer" Process Improvement Team.**
- At the request of Kennedy Space Center, RTI met with Mr. David Thompson at Goddard Space Flight Center. Mr. Thompson is the Chief, **Economic and Commercial Crime Division, Victoria, Australia.** Mr. Thompson was visiting the United States to discuss applications of U.S. technology, including NASA technology, to combat computer crime. The meeting was hosted by Don Vargo (GSFC) and attended by Ray Gilbert (HQ) and Kevin Jackson (NIC).
- Stephen Lehrman participated as a member of the **Lewis Research Center Process Improvement Team on Secondary Targeted Technology Transfer.** The Process Improvement Team was chaired by Bruce Banks. Mr. Lehrman helped identify barriers to secondary targeted technology transfer, proposed solutions to overcome these barriers, and evaluated the likelihood that the solutions could be implemented and their effectiveness.
- The RTI Applications Team continues to work on NASA's behalf to finalize the **Umbrella Space Act Agreement with the National Center for Manufacturing Sciences.**
- Doris Rouse met with Joe Ray, Director of the **MidWest RTTC**, to discuss closer collaboration in support of NASA's technology transfer objectives.
- RTI provided a project summary to K. Thompson of the Kennedy Space Center. The summary covered the history of the **electrically conductive polymer/corrosion resistant coating technology transfer effort.** In addition, RTI drafted a letter to be sent from NASA to the Secretary of the Department of Energy. The letter asks that the funding for the Los Alamos Cooperative Research and Development Agreement be reviewed and facilitated.
- RTI participated in the **1993 NASA Technology Transfer Conference, South Lake Tahoe, CA, April 5-7, 1993.** The meeting provided an opportunity to improve networking with all elements of the NASA Technology Transfer Network.
- RTI prepared a one-page "inside" marketing tool to expand awareness of the Technology Applications Team services within NASA Centers and Program Codes. This information sheet has been used in discussions with technical divisions at NASA LaRC and with program codes at NASA HQ.
- RTI prepared and submitted a white paper to Frank Penaranda for a **NASA Industry Associations Outreach Initiative.**
- At the request of the **Mid-Continent RTTC**, RTI investigated the field of telemedicine in order to provide recommendations to the RTTC in implementing their

telemedicine demonstration project (using the digital funduscope developed at JSC). RTI provided a report summarizing certain telemedicine projects including those that will use the new ACTS satellite. In addition, we provided contacts at two companies which expressed interest in collaborating in this project.

- A consultant to the Applications Team provided an assessment to NASA HQ on a project concept proposed by Russell Eberhart to develop an intraocular pressure control system.
- The RTI Team met with Stan Sadin and Bob Norwood of the NASA HQ Code C, Advanced Concepts Division on April 23 to discuss ways the Technology Applications Team can help Code C develop dual-use technology transfer projects.
- RTI attended a briefing on the **Technology Reinvestment Project** managed by ARPA so that the Team could look for areas where this program can further the objectives of the NASA technology transfer efforts.
- RTI provided a **white paper for marketing of new technologies and patents** for Langley Research Center.

2.0 BASIC CONTRACT STATUS

This section summarizes the status of the deliverables for the basic Technology Applications Team contract (NASW-4367) with RTI. Status reports for the contract add-on tasks are presented in Section 6.0.

The RTI Team's results in meeting its contract requirements are summarized in Table 1. Problem statements prepared by the Team during the reporting period are presented in Section 4.0. In addition to these new projects initiated during this reporting period, the RTI Team continued to assist the NASA Field Centers in developing and monitoring projects initiated in previous contract periods. The RTI Team's activities in the coordination of these ongoing projects are described in Section 5.0.

The statement of work for the Team specifies that transfer opportunities should be developed in the following five disciplines: (1) Automation/Artificial Intelligence (Robotics), (2) Bioengineering, (3) Electronics, (4) Materials, and (5) Rehabilitation. Table 1 includes a column indicating the classification of each project by discipline.

TABLE 1: Contract Status April 1993 - June 1993				
Problems Prepared by Team	Opportunity	RTOP	Category	Center
Joining Techniques for Advanced Composite Materials (bonding, bolting, welding, fusion...)			M	
Nondestructive Testing of Food Packages	Yes		I/A	LeRC MSFC
Real Time Temperature Measurement of Aluminum Sheet and Plate	Yes		I	GSFC
Reliable Occupant Sensing for Lighting Control	Yes		E	JPL
Sterilization Verification: Residence Time of Food Particles In Pipes			I	
Problems Referred by Field Centers Requiring Significant Team Activity	Opportunity	RTOP	Category	Center
Advanced Regenerative Adsorption Cooling	Yes		I	JPL
Fiber Optic Probe for Early Cataract Detection	Yes		B	LeRC
Gamma Ray Collimator	Yes	Yes	I	SSC
Modular Sensor Conditioning System	Yes		E/B	ARC
Ultrasonic Displacement Amplitude Measurement	Yes	Yes	E	LaRC
Virtual Visual Environment Display (VIVED)	Yes	Yes	B/E	JSC

Center Codes:

KSC = Kennedy Space Center	ARC = Ames Research Center
JPL = Jet Propulsion Laboratory	SSC = Stennis Space Center
JSC = Johnson Space Center	LaRC = Langley Research Center
LeRC = Lewis Research Center	HQ = NASA Headquarters
MSFC = Marshall Space Flight Center	GSFC = Goddard Space Flight Center

Category Codes:

R = Rehabilitation	E = Electronics
B = Biomedical	M = Materials
I = Industry	A = Automation

3.0 TECHNOLOGY COMMERCIALIZATION

Modular Sensor Conditioning System

NASA Ames contacted the Team with a request for assistance in commercializing the Modular Sensor Conditioning System. RTI developed a Technology Opportunity Announcement which was used at Technology 2002 where the system was demonstrated. RTI also identified and contacted 28 companies identified as having a potential commercial interest in the system. RTI scheduled visits by two of the companies to Ames for demonstration and discussions relating to the system. RTI is supporting Ames with the direct transfer of this technology in addition to project development for an Analog Data Module based on the system.

Ultrasound Amplitude Displacement Measurement

The Applications Team is assisting the Langley Research Center in locating a company to license the patented electrostatic acoustic transducer and its use for absolute measurement of acoustic displacement. The Team contacted over 40 companies and has received inquiries from 6. These six will be invited to the commercialization workshop planned in conjunction with the Langley Open House.

Stennis Space Center Predictive Response Algorithm

The Applications Team has assisted SSC in the commercialization of the SSC Smart Sensing technology and the predictive response it employs. RTI developed a series of Technology Opportunity Announcements to enable useful discussion of the technology with potential commercial partners. RTI identified and contacted IVAC, a major medical monitoring company, with whom NASA is now negotiating a Space Act Agreement for a Phase 1 proof-of-concept project. The project scope was the result of an RTI assisted meeting at IVAC on June 30, 1993.

Powder Curtain Prepreg Process

The RTI Applications Team helped the Langley Research Center prepare an announcement for the commercialization workshop for the powder curtain prepreg process. The process is a new way of impregnating carbon fiber tow bundles with polymer powders to produce prepreps. Langley printed the announcement and RTI mailed them to over 25 companies. Two companies, Electrostatic Technologies and Polymer Composites, Inc., expressed sufficient interest to be invited to the workshop to be held in July.

Gamma Ray Collimator

The RTI Applications Team is helping the Stennis Space Center find a licensee or commercial development partner for the gamma ray collimator. The collimator is an instrument that focuses gamma rays on an object under inspection. RTI is preparing a mailing to over 20 companies announcing the availability of this technology for licensing or cooperative development.

Virtual Visual Environment Display

The RTI Team prepared a Technology Opportunity Announcement (Appendix B) for the Virtual Visual Environment Display (VIVED) from Johnson Space Center. The TOA briefly describes the technology used to go from CT or MRI scans to three dimensional graphics for educational displays. Other applications of the technology are discussed as well. Johnson Space Center is seeking a commercial partner who will use the VIVED technologies to develop commercial software for education, training, and other purposes.

The Announcement was sent to JSC for use at a conference June 26. In addition, RTI developed a list of target companies and mailed the TOA to them. We also mailed the TOA to the six RTTCs for their assistance in locating a commercial partner. In the next quarter RTI will continue efforts to locate a commercial partner and will assist the JSC staff in locating opportunities, such as conferences, to expand the exposure of this technology to the target audience.

Fiber Optic Catheter for Early Cataract Detection

Working from NASA reports and scientific articles, RTI developed a Technology Opportunity Announcement (Appendix B) describing the Fiber Optic Probe for Cataract Detection from Lewis Research Center. We are currently obtaining NASA review and developing a targeted mailing list. The TOA will be distributed in July 1993.

Marshall Space Flight Center Technology Commercialization

The MSFC Technology Utilization Office requested the Applications Team to identify and assess existing MSFC technologies as potential commercialization candidates. Following assessment two to three technologies will be selected for marketing.

4.0 NEW PROBLEM STATEMENTS

PROBLEM TITLE: Residence Time of Food Particles
in Stainless Steel Pipes

SOURCE OF PROBLEM: National Food Processors Association

RTI TEAM PERSONNEL: Molly O'Donovan Dix

DATE OF PREPARATION: July 27, 1993

I. TECHNOLOGY REQUIRED

The food-processing industry, represented by the National Food Processors Association (NFPA) with over 500 members companies, seeks a noninvasive method to measure the time an individual particle takes to move through a length of 316 stainless steel pipe. A food product in two-phase flow (liquid with solids) passes through the pipe with pressures of approximately 60 psig and temperatures of 270-285°F.

II. BACKGROUND

Problem and Impact of Solution

Traditional food processing uses a retort process in which the product and its container are sterilized together. However, in some applications an aseptic process is used. In this process, the food is sterilized at high temperatures for short periods of time (20-120 sec.), the package is sterilized separately, and the two are brought together in a sterile environment where the container is filled with the food and sealed. The aseptic process provides better control and higher quality taste to the end product.

Although products such as juice in juice boxes, milk, and ice cream can currently be processed using the aseptic method, foods with particles, such as stews and spaghetti, cannot be because there is no FDA-approved method for determining adequate sterilization. To enable particulate two-phase food processing to utilize this superior process, food processors require a method that provides a velocity measurement of the fastest moving particle passing through a hold tube. If the fastest particle remains in the tube for a minimum time, the food can be identified as adequately sterilized.

Specifically, the food industry seeks a noninvasive method (i.e., one that does not impede the product flow) to measure the time it takes for a food particle to move from one end of the tube to another. The mean velocity of all the particles cannot be used since there is a

velocity distribution. Ten to twenty of NFPA's member companies have an interest in this method since they are looking for a method to determine the shortest residence time over a statistically representative number of particles. This information will be used to determine if the food has been properly sterilized. Safety of the food product is of primary importance to this industry. The system could be used in the United States and internationally to provide better tasting and safer processed foods for consumers.

Beef stew is a typical food product that cannot currently use aseptic processing but would gain in product quality if it could. Beef stew, and other products that would benefit from a measurement process, typically have an opaque base (starch in the case of stew) and particles in suspension, such as beef or vegetables. These particles are typically larger than 1/4" cubes. The food is processed by pumping the food product through a heat exchanger to heat the product, a hold tube to sterilize the product, and a heat exchanger to cool the product. The hold tube is constructed of 316 stainless steel which is 0.065" thick. The temperature inside the particle and the time it takes to flow through the hold tube will determine if the food particle is adequately sterilized.

III. STATE OF THE ART

Two methods are currently in use.

1. *Method.* Small magnets are embedded into tracer particles to detect a change in emf as the particles pass by detector coils. The particles with magnets are released into the product stream at time zero, passing a sensor to start timing. The first magnet particle that passes a second sensor down stream is the fastest particle among that test group.

Limitations. This method can only be used in large particles (1/2" or larger), since typical detectable magnetic particles are 1/2". Magnets this size may alter the density of the particle, and thus the flow characteristics. The magnetic particle size coupled with the electric noise (rf, emf fluctuations) in the processing area from motors and other sources, limits the value of this method.

2. *Method.* A visual method has been tried using glass sections placed in the pipe.

Limitations. This method is only possible if the fluid is clear. Furthermore, other particles obscure the test particles, preventing accurate velocity measurement.

IV. TECHNOLOGY SPECIFICATIONS AND CONSTRAINTS

The procedure must be noninvasive to the extent that it does not impede or alter the food product flow. It must measure the time an individual particle takes to move through a stainless steel pipe from point a to point b. Particles are 0.25 to 1 inch in size (e.g. meatballs, ravioli). Glass sections can be mounted at the test points if necessary; however, this is undesirable due to the expense required and because the food product is generally opaque. Many other particles will be in the pipe (the food product) in addition to the particle of interest.

The food product is generally a low acid ($\text{pH} > 4.6$) food in two-phase flow (liquid with solids) and does not transmit light. In the standard processing system, the food flows through a 316 stainless steel pipe, with outside diameters typically 1.5 to 2 inches, and lengths of several hundred inches. The tube slopes upward to eliminate air pockets and prevent self-draining. Free space surrounds the tube, and instrumentation can be mounted at the ends.

The temperature inside the pipe may range from 270°F to 285°F (usually 1-2°F variation over time) with pressures of approximately 60 psig. The test system will not be installed permanently but will be installed for testing purposes only, therefore the test unit should be semi-portable.

The method should not use hazardous or toxic materials. One possible solution is to mount a small object with the same density as the food product (1 to 1.2 g/ml) into a particle or mark a particle that can be detected as it passes by a sensor. If a method uses a device mounted in the particle, it should not have an appreciable effect on the density of the particle. This device should not be affected by pressures in excess of 100 psig and temperatures up to 300°F. This implantable device should be relatively inexpensive (\$1 or less) and preferably reusable.

Other possible technologies include ultrasonic techniques, two-phase flow measurement devices, or any other applicable sensor or technology enabling the velocity measurement of the fastest particle through the hold tube.

5.0 COORDINATION OF ONGOING PROJECTS

PROBLEM TITLE: Contextual Alarm Management System (CALMS)

SOURCE OF PROBLEM: National Special Education Panel

RTI TEAM PERSONNEL: Dean Hering
Daniel Winfield

Background

Technologies are needed to provide modularization, integration, and portability of medical monitors and life support units for children in order to reduce the management requirements of multiple system operation.

Due to medical advances and recent federal legislation, an increasing number of medically fragile children are in evidence in the public schools. The medical monitoring and life support needs of these children can be complex. As hospitals release these children to their families, both parents and school staff are required to learn to operate a variety of medical equipment usually found only in medical facilities. Monitoring devices include apnea monitors, devices which monitor heart rate, oxygen saturation, fluid retention, seizures, etc. Life support systems include those which provide nutrition, ventilation, suction, medical drips, dialysis, etc. Children are often connected to several such devices which are then transported to and from school and into the community on family outings. There is a need for a single, modular monitoring device which can incorporate multiple devices as needed in order to reduce the amount of equipment needed by an individual child and still meet the medical needs of that child. Additionally, parents and care-providers report that when alarms sound, they are sometimes unable to identify the source of the problem because the child has so many, similar sounding alarms and buzzers. A system which integrates these alarms and presents the information clearly to care-provider would greatly enhance the effectiveness of the equipment.

Several leading medical monitor manufacturers indicate that alarm management and coherent instructions for care-providers via displays on monitoring systems are of great interest to their industry and would provide worthwhile opportunities in the medical monitor device market sector.

NASA Technology

The Biomedical Risk Assessment Intelligent Network (BRAIN) technology developed by KRUG Life Sciences for NASA Johnson Space Center was identified as a potential

match for the problems specified in the problem statement. BRAIN is an artificial intelligence based system that uses a knowledge base to assess biomedical risks. Given medical monitor inputs and an appropriate knowledge base, researchers at KRUG and NASA feel that BRAIN can be adapted to provide an assessment of alarm conditions and interactions generated by multiple monitors.

Participants

- Dr. Karin Loftin, KRUG Life Sciences
- Mr. Bill Norfleet, NASA JSC
- Dr. Jeff Feldman, Albert Einstein Medical Center
- Ms. Gayl Bowser, Oregon Department of Education
- Major Medical Monitoring Company (the company)*

**For competitive reasons, this corporation requests their name to remain confidential. This company is a leading medical monitoring manufacturer with 1991 revenues exceeding \$180 million for their monitors.*

Status

The Team held several teleconferences during which Dr. Feldman, Dr. Loftin, and Mr. Hering developed a project plan for developing a Contextual Alarm Management System (CALMS). CALMS is a generic alarm management system to detect and remove artifacts from medical monitor signals and utilize multiple monitor signals to determine and manage alarm situations.

The company sent a letter to JSC committing \$300,000 support to the project. RTI organized and participated in a project planning meeting at JSC in August at which the actual medical signals and conditions to be used for the prototype were finalized, roles and responsibilities were assigned, and the Project Plan initiated.

RTI coordinated several teleconferences between JSC Legal and the company legal to develop the Space Act Agreement. In January, RTI contacted Jack Mannix, NASA HQ Code G, who assisted Johnson Space Center and the corporate partner in arriving at a mutually beneficial intellectual property arrangement for the Contextual Alarm Management System Space Act Agreement. The Agreement was signed by the partner and sent to JSC legal on March 26, 1993. Following a series of reviews, the Space Act Agreement was signed by JSC in June 1993. Subsequent to this signing, the Company entered into negotiations with Dr. Feldman for a contract to support his portion of the project.

Action

RTI will coordinate a kick-off meeting of the project participants to resolve any further items, revise the project schedule due to SAA delays, and turn over project management to the participants. RTI will monitor project progress.

PROBLEM TITLE: Digital Mammography System

SOURCE OF PROBLEM: National Cancer Institute
Diagnostic Imaging Research Branch

RTI TEAM PERSONNEL: Daniel Winfield

Background

In 1993 approximately 186,000 women will be diagnosed with breast cancer and 47,000 women die. In all, one in eight women can expect to be affected by breast cancer at some time during their lives. Screening and early diagnosis are currently the most effective ways to reduce mortality from breast cancer. The widespread acceptance of mammography as an important tool for the screening and early diagnosis of breast cancer has resulted in a proliferation of dedicated equipment and associated technologies. Nevertheless, there are several technical factors which limit the ability of film-based mammography to display the finest or most subtle details, and produce images with the efficient use of radiation dose to the patient. There is an increasing need to overcome the technical limitations, improve image quality, and, at the same time, satisfy the requirements for low radiation dose and cost effectiveness. There is no doubt that computer workstations combined with recent technological developments in direct digital x-ray detection systems, advanced image processing and pattern recognition methods, and customized very large scale integrated (VLSI) circuits hold a major part of the solution to the escalating demands of this medical imaging modality.

The National Cancer Institute has targeted digital mammography as a priority need and is working with the Technology Applications Team to locate the best available technologies under development within federal laboratories for application to this problem.

NASA Technologies

Forty five responses were received from various federal labs including eighteen from NASA Field Centers. Following evaluation by NCI experts, the following technologies were selected for in-depth evaluation:

CCD-based imaging detectors (JPL, LaRC, MIT Lincoln Lab and U.S. Army Armament R&D Center)

Solid State Imagers with Scintillation Fibers (Lockheed and Nanoptics)

High resolution, high brightness displays (National Information Display Lab)

Wavelet transforms for pattern recognition (LeRC)

Analog and digital VLSI implementations of image processing (JPL)

Pattern Recognition software (Naval Surface Warfare Center, Lawrence Livermore National Lab, and U.S. Air Force Wright Lab)

Image compression software and hardware (JPL and LeRC)

Cesium iodide scintillators in amorphous silicon (Lawrence Berkeley Lab)

Thin film detectors (Nova R&D)

All optical, tunable high speed networks (MIT Lincoln Lab)

Participants

Dr. Faina Shtern

National Cancer Institute

Four scientific advisors to NCI

(Dr. L. Clarke, Univ of South Florida;
Dr. M. Yaffe, Univ. of Toronto;
Dr. J. Blaine, Washington Univ.;
and Dr. K. Doi, Univ. of Chicago)

NASA participants to be determined .

Status

NCI scientific advisors visited several federal labs and contacted others by phone to discuss their technology expertise in image processing, pattern recognition, CCD detectors, and analog and digital VLSI implementation. These advisors completed their evaluation and the list of candidate technologies was narrowed to the above list.

Plans were initiated to conduct a workshop to accomplish two objectives:

1. More in-depth evaluation of the application potential of each technology.
2. Involvement of the medical device industry to begin forming partnerships for development.

The RTI Applications Team organized and chaired a Digital Mammography Workshop in Bethesda, MD on May 19-20, 1993. Invitations to industry invitees were coordinated through the National Electrical Manufacturers Association Division in Diagnostic Imaging. Over 90 people (including 28 industry reps) participated in the meeting which was unanimously judged a huge success. The format contributed greatly to helping participants assess the applicability of each of the candidate technologies.

In follow-up to the workshop, RTI contacted many of the participants to identify a number of collaborative efforts in the formative stage. The results of the workshop were

reported to the NASA-NIH Advisory Committee which responded favorably to this effort.

Action

A meeting of the NCI-NASA Work Group has been scheduled for July 27, 1993 to define avenues for joint support of innovative technology applications projects. RTI will support this meeting and subsequent action items.

PROBLEM TITLE: Early Language Intervention System (ELIS)

SOURCE OF PROBLEM: National Special Education Panel

RTI TEAM PERSONNEL: Stephen Lehrman

Background

An Intelligent Computer Aided Training system is needed to provide initial language instruction to young children at risk for developing disabilities and children who have not yet developed basic language skills and concepts. Recent legislation from the federal government puts an increasing emphasis on the early education of children with disabilities. The Individuals With Disabilities Education Act (IDEA) provides for early intervention in the education of children with disabilities from the age of three. Programs such as Head Start and state mandated programs for early intervention and education of children at risk for developing disabilities may serve children from the age of three months.

A primary focus of early intervention programs and special education programs for young children is the development of basic language and communication skills. Without a firm understanding of basic concepts, children will be unable to succeed in school programs. Education research has indicated that the use of computers with speech output to teach emerging language skills can significantly increase the language skills of young children with disabilities.

While a number of computer programs for teaching isolated language concepts and vocabulary items are available for use with children who are learning initial language skills, these programs are generally based on a drill and practice model. The programs present a series of questions to which the child must respond. While these questions may be presented in random order, the programs do not adjust the content of the tasks based on the responses of the child and are insensitive to the way the individual student learns. In addition, programs generally present "splinter" language skills in isolation. This bits and pieces approach does not provide the integrated approach necessary to smoothly develop a child's language skills. The quality of computer based language instruction is currently based on the ability of the educator to select appropriate software at the appropriate moment.

An Intelligent Computer Aided Training (ICAT) system with voice output and integrated language training using expert systems techniques to decide which skills to teach would extend the expertise of early intervention and special education teachers and help deliver

timely individualized emerging language instruction. An ICAT system can compare a student's performance with a system model for the exercise, evaluate the student's progress and mastery, catch mistakes, provide extra practice in areas of difficulty, and provide feedback to guide the student in solving the problem correctly. This approach provides much more individual attention that students often miss in class or do not receive from conventional software packages.

The curriculum/rule base will be developed by or in conjunction with a panel of educators and speech therapists identified by the Special Education Panel. This problem is one of two identified by a National panel of special education practitioners convened by the Department of Education's Center for Special Education Technology. This panel is working with the Applications Team in a special initiative to apply technology to needs in special education. Researchers in NASA JSC's Software Technology Branch responded in February with an interest in using the ICAT system used by JSC for the Physics Tutor and an adult literacy tutor.

NASA Technology

Researchers in NASA JSC's Software Technology Branch responded with an interest in applying the ICAT system used by JSC for training shuttle crews and ground personnel. The ICAT system is an expert system based platform that captures the knowledge of training staff for use in computer training systems. The system adjusts the exercises and training to the student's progress, providing more training in weak areas and less in strong areas, and provides an evaluation for the teacher. This approach allows the student to have instruction similar to a one on one session with a tutor.

By rewriting the rule base, capturing the knowledge of special educators and otherwise adapting the ICAT system to the special education environment, the same technology can be applied to help develop the early language skills of young special education students. The requirements for doing so involve locating a leading special education software company with successful products for the target age group, knowledge of teaching reading skills, and the manufacturing/distribution system for commercializing the technology.

Participants

- Bowen Loftin, NASA JSC
- Bob Way, Computer Sciences Corporation (for NASA)
- Mary Wilson, Laureate Learning Systems
- Bernie Fox, Laureate Learning Systems

Status

The RTI Team was instrumental in drafting a Space Act Agreement which has been signed by NASA JSC and Laureate Learning Systems (LLS). As a result of LLS moving to a different location and the JSC Software Technology Branch working on NASA mission related activities, communications between them have been impaired. After Dr. Bowen Loftin brought this issue to RTI's attention, RTI initiated a series of telephone conference calls between LLS and JSC. The purpose of the conference calls was to review the progress of the project, identify unresolved action items, and revise the project schedule accordingly.

The results of the telephone calls included a reaffirmation that the original project plan was still valid. Mr. Bob Way of JSC travelled to LLS and worked with the LLS programmer on developing the graphical user interface. This interaction was very profitable in terms of progress in the project. LLS promised to send JSC written requirements for the animation and how the student will interact with ELIS.

Action

RTI is assisting the project team with administrative details as necessary. The Team will also support documenting the project's progress and commercial products as they become available.

LLS will provide JSC written requirements for the animation and how the student will interact with ELIS.

PROBLEM TITLE: Ice Detection and Thickness
Measurement System

SOURCE OF PROBLEM: Johnson Space Center

RTI TEAM PERSONNEL: Dean H. Hering
C. Gary Hughes

Background

This project was pursued at the request of Dr. Dickey Arndt, Chief of JSC's Electromagnetic Systems Branch. Dr. Arndt's Branch performed research and developed, with NASA contractor Stolar Research Group, a laboratory demonstrable ice detection and thickness measurement system for use on the Space Shuttle's external tank. Dr. Arndt and his staff realized that the ice detection system offered a novel approach to ice detection which might interest outside groups. Such groups include the FAA, interested in new techniques to prevent accidents such as the several recent airplane accidents in Washington, DC., Denver, Colorado, and Europe caused by ice and snow build-up on aircraft.

The JSC sponsored sensor overcomes several problems plaguing current sensors, including the ability to perform accurate measurements when a layer of water or water-ethylene glycol (deicer) is present. The small size of the JSC sponsored ice detector also lends itself to flush mounting, eliminating the possibility of creating an additional icing surface on the aircraft.

Participants

- Dickey Arndt, JSC
- Andrew Chu, JSC
- Larry Stolarczyk, Stolar Research Group, RIMtech
- Charles Masters, Federal Aviation Administration (evaluator/advisor)
- David Minsk, Strategic Highway Research Program (evaluator/advisor)

Status

After discussing the work with JSC, RTI contacted Mr. Charles Masters, manager of the FAA's Aircraft Ice Research and Development Program. Mr. Masters reviewed the technical report and in May, 1992, visited JSC and discussed the FAA's needs with NASA. He indicated that current ice detection systems are unsatisfactory. He will also

include Dr. Stolarczyk's report in the FAA's forthcoming report on technologies for detecting ice.

RTI assisted Dr. Stolarczyk in preparing for the FAA conference on icing. Dr. Stolarczyk participated in the meeting, which included manufacturers, airlines, pilots, and the FAA. Dr. Stolarczyk met with a number of manufacturers and airlines and as a result of the conference met with United Airlines at the end of June, 1992.

The Team also contacted the Strategic Highway Research Program (SHRP) to discuss the potential application of the ice detection system to highways and bridges. Mr. David Minsk, Project Manager, Snow and Ice Control for SHRP reviewed the material and indicated interest. Mr. Minsk recommended that Dr. Stolarczyk and RTI participate in SHRP's Expert Task Group meeting. The expert group, consisting of manufacturers, Department of Transportation, other government, and university representatives, represents the best group to review the applicability of the ice detection system for the nation's highways and bridges.

In September, 1992, *Commercial Aviation News* outlined an upcoming FAA requirement that requires airlines to submit, and have approved by November 1, a de-icing plan outlining the procedures they will follow when ground conditions could lead to frost, ice, or snow adhering to aircraft surfaces. This followed the March 22, 1992 USAir crash at La Guardia airport that killed 27 passengers.

The NASA/RIMtech ice detection system provides a means to meet this requirement and reduce the accidents caused by icing on aircraft and on this nation's highways. RTI met with contacts at the Federal Highway Administration and took them to JSC's booth at Technology 2002 for a demonstration. As a result, RIMtech was invited and presented the technology to the Transportation Research Board as part of the Federal Highway Administration's Smart Highways Conference. This technology could provide automatic notification to motorists of dangerous conditions. *Motor Week* and *The Wall Street Journal* interviewed Dr. Stolarczyk; *The Wall Street Journal* followed up with airline companies and manufacturers to assess the state of the market. The system was included in the January 11, 1993 issue of *Aviation Week and Space Technology*.

RTI has performed a state-of-the-art review for aircraft and pavement applications of the ice detection system and forwarded the results to JSC for incorporation in the project plan activities. Industry has committed 85% of the funding, \$960K, required for the remaining technology development and commercialization. NASA JSC submitted a new start RTOP for the remaining 15% (\$160K). The 5.7 to 1 industry to NASA co-funding ratio and participation of the FAA and SHRP provide excellent mechanisms for producing a highly useful and successful commercial ice detection system from the NASA

sponsored technology. JSC issued a request for proposal to provide the necessary leveraged technology development.

Action

RTI will monitor and document the project's progress, and assist in the initial project phase.

PROBLEM TITLE: Medical, Electrolytic Oxygen Concentrator
SOURCE OF PROBLEM: Florida Solar Energy Center
RTI TEAM PERSONNEL: Daniel Winfield

Background

It is estimated that 2 to 4 million cardiopulmonary patients in the U.S. require supplementary oxygen; approximately 500,000 patients require continuous oxygen therapy. Current means to supply oxygen include compressed oxygen cylinders (heavy and expensive); liquid oxygen (cryogenic and expensive); and sieve-bed oxygen concentrators (heavy and bulky). While many patients can be served with oxygen concentrators which use the molecular sieve technology, weight, size and power requirements for these systems preclude their ambulatory application. People are forced to turn to the gaseous or liquid oxygen, but these technologies suffer from several drawbacks. Both are relatively expensive and require delivery of replacement cylinders or canisters. They provide a limited supply of oxygen, and thus cannot be used for extended periods. Gas cylinders are heavy and liquid oxygen canisters require cryogenic storage.

Demand cannulas have been introduced in recent years which reduce the flow rate requirements. This allows an oxygen cylinder to last longer during ambulatory use. However, these cylinders are still heavy, rather expensive, and require delivery from a gas cylinder supplier. The subject project seeks to provide an ambulatory oxygen concentrator which provides a reduced flow rate for use with demand cannulas. Progress is needed to reduce size, weight, and power requirements.

NASA Technology

NASA has supported work at Kennedy Space Center investigating electrolytic processes for oxygen extraction from the atmosphere. In 1991, NASA supported R&D at the Florida Solar Energy Center (FSEC) developing the basic technology for a solid polymer electrolyte system. The solid polymer electrolytic oxygen concentrator (SPEOC) will ultimately address the above limitations and may lead to the first truly portable oxygen concentrator for home medical use. The SPEOC electrochemically extracts oxygen from air at near ambient pressures and temperatures. With the advent of modern polymers capable of a high degree of ion conductivity and process resilience, it is now possible to perform electrolysis in solid membranes (e.g., perfluorinated sulfonate ionomers). Based on work conducted for Kennedy Space Center, FSEC researchers have built a small prototype SPEOC unit and are experimenting with approaches to increase current density and thus efficiency of oxygen transport.

Participants

- Ali T-Raissi, Florida Solar Energy Center
- Mike Lonergan, NASA Kennedy Space Center
- George Cavagnaro, Healthdyne Technologies, Inc.

Status

On initiation of the project in 1991, a start-up company was involved for commercialization of the technology. However, that company has since dropped from the project due to inability to negotiate a license agreement with the FSEC. Recognizing the need for a commercialization plan, NASA KSC asked the Applications Team at RTI to assist in securing a commercial partner for this project. RTI worked with the principal investigator at FSEC to develop a technology opportunity announcement summarizing the technology, its application, and current development status. This announcement was mailed to eighteen companies in the respiratory therapy market. Eight companies expressed active interest, and three have visited FSEC. RTI assisted FSEC in developing a detailed project plan and funding estimates. Negotiations are now complete with Healthdyne Technologies, a leader in the medical oxygen concentrator market, agreeing to project cost and co-funding schedules. In return for their financial support, Healthdyne will receive an exclusive license to the technology. In addition we have involved the Florida Technological Research and Development Authority (TRDA) in the most recent meeting with Healthdyne, TRDA has tentatively agreed to match any future NASA funding amounts.

Upon review of the legal agreement between Healthdyne and the Univ. of Central Florida (UCF), UCF determined that two documents were required: a research agreement and a licensing agreement. Following delays as Healthdyne Technologies was taken public, these revised agreements have been prepared and are ready for final approval.

Action

RTI will assist as necessary in execution of the agreements and will monitor further project progress.

PROBLEM TITLE: **Nondestructive Testing of Food Packages**

SOURCE OF PROBLEM: **National Food Processors Association**

RTI PERSONNEL: **Molly O'Donovan Dix**

Background

The food processing industry, represented by the National Food Processors Association with over 500 member companies, seeks new methods and technology for nondestructively testing food packages for leaks, which may be as small as 25 to 100 microns, and contamination. The ideal situation would be to test every package during routine processing without requiring changes in the packages.

Food processors are required by law to assess the integrity of the packages they distribute. Package defects are rare--they occur in approximately 1 in 10,000 packages under optimal conditions and approximately 1 in 5,000 on average. However, the consequences of container failure are enormous. Examples exist of entire food industries, covering several countries, becoming paralyzed or even collapsing due to a defect in one package. The food packaging industry spends millions of dollars a year on testing package integrity to prevent package defects that can unleash a loss of consumer confidence and paralyze the market.

The principal function of food packaging is to prevent the contamination of food products by bacteria, thus protecting its wholesomeness and purity. Health concerns resulting from bacterial contamination will vary according to the type of microorganisms supported by the particular food type.

Packages are made of glass, metal, paper, and plastic--each with different closure designs. Packages must serve many functions and, because every feature adds cost, most food packages are optimized and stripped to the bare essentials. They provide barriers to bacteria, aroma, moisture and oxygen; provide stacking strength and abuse resistance; fit into the hand; suit consumers lifestyles; and are convenient, resealable, microwaveable, and, above all, reliable. Packages are designed to market food--not to be tested easily. Methods must be devised to test packages that do not require changing the packaging itself.

Testing is used by the food industry to identify, isolate, and prevent microleaks in food packages. Almost all testing involves removing samples from the production line and uses methods that destroy the packaging in the process. This line sampling and destructive testing is inefficient, expensive, and wasteful. The food processing industry seeks

new technology to replace this testing method with a non-destructive method. On-line nondestructive tests offer several advantages:

- Better precision than human inspectors
- More consistency in accept/reject decisions
- Better day-to-day reliability
- Ability to evaluate every package.

There are 19 test methods, each modified to work best with a container shape, closure or material, that are used to test food packages for microleaks. Although each test method has its advantages, there are also disadvantages to each. Limitations include:

- Most tests must be conducted in a laboratory using specialized tools.
- Some tests, like incubation, are slow.
- Most require sample packages from the production line or the warehouse.
- Detecting a very small, but significant defect is limited by statistical sampling methods.
- Skilled personnel are required to detect package defects on a fast-moving conveyor belt.
- Most current tests destroy the package.
- Special fixtures are required to attach sensors to the packages for nondestructive testing.

The biggest limitation of destructive tests is that they destroy the package. Nondestructive testing offers speed, reduced product loss, increased line efficiency, and the possibility of 100 percent inspection. Existing on-line nondestructive testing devices can cost up to \$500,000. New or untried nondestructive test methods could significantly improve the rate of package defect detection over current testing methods.

This is the first of several problem areas identified by the National Food Processors Association.

NASA Technologies

Many methods from other industries have been largely untried on food packages. Possible solutions include but are not limited to:

- Video image processing
- Ultrasound methods that do not require direct coupling
- Laser scanners
- Force measurement systems (to measure forces necessary for bacteria to pass through micron-sized holes)
- Sensors that can be incorporated into labels indicating bacteria within a sterilized container
- Remote sensing technology
- Radar methods to detect openings.

Participants

- Dr. Lester Crawford, Executive Vice President, Scientific Affairs, National Food Processors Association
- Dr. Jeffrey Barach, Vice President Eastern Research Laboratory, National Food Processors Association
- Mr. Austin Gavin, National Food Processors Association
- Dr. Barbara Blackistone, National Food Processors Association

Status

The problem statement was distributed to the Field Centers in January. It was subsequently sent to other federal laboratories via the Federal Laboratory Consortium, in accordance with the NASA/FLC agreement. Twelve responses were received including NASA, NIH, USAF, USDA, and DOE.

Following review by the National Food Processors Association's industrial subcommittee, three technologies were selected for further discussions. The three technologies being considered are from DoE and NIH.

Action

RTI will arrange conversations with the researchers to follow up on promising matches. Following that, RTI will pass along the opportunity to the appropriate technology transfer contact at each researcher's facility. All of the responding researchers will be updated regarding the final outcome.

PROBLEM TITLE: Real Time Temperature Measurement
of Aluminum Sheet and Plate

SOURCE OF PROBLEM: Aluminum Association, Inc.

RTI TEAM PERSONNEL: Stephen A. Lehrman

Background

Hot rolling of aluminum sheet and plate requires accurate temperature monitoring for feedforward and feedback control of the rolling mill. Bars 40-80 inches wide enter the mill at less than 100 ft/min and exit as hot rolled coils at approximately 1000 ft/min. Surface temperature is typically measured using infrared pyrometers or thermocouples.

Infrared pyrometers are manufactured by many companies. Infrared pyrometers look at the radiated light off the surface of the aluminum product and calculate the surface temperature. Most infrared pyrometers operate at a wavelength below 4 micron. The amount of radiated light is affected by the emissivity of the aluminum and by reflection from bright lights in the work area. The emissivity of aluminum product is very low (≈ 0.1) and is a function of the aluminum temperature, composition of the alloy, process conditions, surface finish, state of oxidation of the surface, and wavelength at which the measurement is performed. The influence of each factor on the emissivity of the aluminum surface can vary greatly. Bright lights also cause reflection off the aluminum surface which introduces errors into the infrared pyrometer measurement. Under relatively constant process and environmental conditions, commercial infrared pyrometers can measure the surface temperature to ± 10 °C over the required temperature range.

Thermocouples are contact temperature measurement instruments. Because they must be in direct contact with the material to be measured, thermocouples are difficult to use on moving aluminum sheet and plate. Aluminum rolling mills have not been able to achieve the desired temperature accuracy using thermocouples.

The temperature measurement instrumentation must be able to measure the surface or bulk temperature of aluminum sheet and plate moving at 1000 ft/min without contacting the material. The required accuracy is ± 2 °C at 50 °C to ± 5 °C at 600 °C. The instrumentation must be able to operate continuously, 24 hours a day, in an environment that contains steam in the air, dust, vibration, electrical noise, electromagnetic fields, and bright ambient lighting. The environmental temperature ranges from 0 °C to 100 °C. The instrumentation should be easily calibrated, reliable, and exhibit no drift. The sensor head should be located a reasonable distance away from the aluminum surface,

although this requirement is flexible. The instrumentation should be able to measure the temperature at multiple points across the width (40-80 inches) of the aluminum product. Either a sensor array or scanner is acceptable. The instrumentation should be able to transmit temperature information to the rolling mill computers for process control. Commercial instrumentation, once developed, should not cost more than \$20,000 per measurement station.

NASA Technology

A total of five responses were received from NASA Goddard/Wallops Island, Los Alamos National Laboratory, Oak Ridge National Laboratory, Lockheed/NASA White Sands Test Facility, and the University of Arkansas-Little Rock. All responses suggested some form of optical pyrometry.

Dr. Kate Forrest of NASA Goddard/Wallops Flight Facility recommended triple wavelength infrared pyrometry implemented with commercially available, state-of-the-art uncooled detector array technology. All three wavelength would be in the far infrared from 8 to 12 micron. This wavelength band is particularly appropriate for measuring the temperature of aluminum because the emissivity of aluminum varies about half as much at these wavelengths as it does at lower 2 to 4 micron wavelengths. Even more importantly, between 8 to 12 microns the emissivity of aluminum varies linearly to a high degree for temperatures between 0° and 750°C, and the linearity is strongest at lower temperatures where accurate measurement is most difficult.

Participants

- Mr. Seymour Epstein, Aluminum Association
- Mr. Otto Meijer, Alcan Rolled Products Division

Status

Mr. Meijer stated that the Aluminum Association sub-committee on temperature measurement of aluminum sheet had reviewed all the proposals submitted. Mr. Meijer stated that, at this time, the Aluminum Association was going to proceed only with funding the present work at the National Institute of Standards and Technology on using eddy current methods for determining the aluminum temperature.

Action

The Applications Team plans to continue to discuss this project with Mr. Meijer and Mr. Epstein on a regular basis. If the eddy current method fails to provide accurate temper-

ature measurements, or if the Aluminum Association desires to try an advanced pyrometry approach, the Team will be prepared to initiate a cooperative project.

PROBLEM TITLE: **Reliable Occupant Sensing for Lighting Control**

SOURCE OF PROBLEM: **Manufacturer of lighting products**

RTI TEAM PERSONNEL: **Molly O'Donovan Dix**

Background

Today's environmental awareness and the resulting political climate limit construction of new power generating facilities. Emphasis is now placed on renewable energy sources and energy conservation. To continue supplying power at the ever-increasing level of demand, utilities are looking to their customer's systems and equipment for efficiency improvement opportunities.

A common technology encouraged by utilities in the residential, commercial and industrial sectors is lighting control based on occupant sensing. Numerous utilities currently offer some kind of incentive to customers for installation of occupant based lighting control. In addition to lighting, occupant sensing control is also used for Heating, Ventilation, Air Conditioning (HVAC) control.

Existing technologies (including passive infrared and ultrasonic) used for occupant sensing could be improved in many ways. A more effective or reliable sensing element at a comparable cost may better motivate customers to install devices without incentives from their utility. The entire population gains from conservation efforts and thus a redesign of the existing sensing technologies will have a broad benefit.

System Requirements

- The system should reliably detect a six-inch hand movement at twenty feet.
- The system should have a 180° viewing angle.
- The system should provide a targeted sensitivity to "human" presence to avoid false triggering.
- The system should cost less to manufacture than existing systems. Existing commercial systems typically cost \$10 to \$20 to manufacture. For residential systems the detector must be manufactured for less than \$3.

NASA Technology

None of the NASA Field Centers that responded to the problem statement had existing technologies that could improve on currently available commercial technology. However, applicable technology was identified at the Jet Propulsion Laboratory.

Regent Lighting has expressed interest in JPL's tunneling infrared technology (contact Dr. Thomas Kenny) and long wavelength infrared detector technology (contact Richard P. Vasquez). Both technologies are available for license from NASA.

Status

A technology at Lawrence Livermore National Laboratory was also identified as a potential transfer opportunity. Regent will follow up on this lead independent of TAT services.

Action

RTI will assist Regent in preliminary conversations with the Patent Counsel at JPL. RTI will also outline other contacts which provide access to Federal technologies (NTTC, RTTC, FLC locator) in the event that the JPL technology does not meet commercial needs.

PROBLEM TITLE: **Gamma Ray Collimator**

SOURCE OF PROBLEM: **Stennis Space Center**

RTI PERSONNEL: **Stephen A. Lehrman**

Background

The Stennis Space Center performs nondestructive examination of thick walled pressure vessels. The conventional method for nondestructive examination of these pressure vessels is to have a radiographic source inside the pressure vessel and expose the radiographs in a panoramic fashion. Some of these pressure vessels at Stennis do not have a manway, thereby, preventing this method of inspection.

Existing technology does permit through two-wall radiographic inspection. However, the exposure time is very long (e.g. weeks) and the restricted area may exceed 1000 feet. The Stennis Gamma Ray Collimator uses salt shields to intensify the gamma radiation. The result is an exposure time measured in ten's of hours and safe stand-off distance of less than 100 feet for most applications at Stennis.

Stennis Space Center has requested assistance from the RTI Applications Team in locating commercial partners for this technology.

NASA Technology

NASA has applied for a patent on the gamma ray collimator. The collimator consists of a housing having two sections. The first section encloses a radiation emitting component such as cobalt 60. The second section encloses a depleted uranium member which is provided with a conical cut out for focusing the radiation. Salt screens are used to significantly reduce radiation dispersion. A wheeled, telescopic, robotic arm can be used to precisely position the gamma ray collimator source.

Participants

NASA would like to license the patent to a U.S. company. No participants have applied for the license. Amersham, Source Production & Equipment Company, and Industrial Nuclear provide gamma ray sources and are potential licensees. Also, MQS Inspection and Hartford Steam Boiler are potential field testing participants in a nonreimbursable space act agreement.

Status

The Team contacted Mr. Ron Falloon, Vice President of MQS Inspection, regarding field testing the gamma ray collimator. Mr. Falloon did not believe MQS Inspection would have a use for the equipment. Also Hartford Steam Boiler indicated that they do not perform radiography. Instead, they subcontract the work to small companies.

Action

The Applications Team plans to continue to contact potential partners for testing the equipment and/or licensing the patent, once awarded. Companies and individuals the Team plans to contact are:

SPEC
Amersham
Industrial Nuclear
Radian Corp.

Don DeCherry
Jim Buckenburger
Bill Huddleson
Ron Manson

PROBLEM TITLE: Modular Programmable Sensor Conditioning System

SOURCE OF PROBLEM: Sensors 2000! Program, Ames Research Center

RTI PERSONNEL: Molly O'Donovan Dix

Background

NASA Ames developed a modular, programmable sensor conditioning system for physiological monitoring on the Space Shuttle. This system's modular construction makes it well suited to a variety of sensor applications. The NASA system, which is completely developed, has commercial potential for physiological measurements, process control, and other sensor signal conditioning applications.

NASA Technology

The system as it exists consists of a 12-slot distributed-function backplane, seven signal conditioning cards, a three-card digital control and memory system, and two power supply cards for conditioning and isolating the output of the external power supply. The signal conditioning cards may be configured to process different sensors. The modular design also allows new signal conditioning cards to be inserted for different applications. Each card filters the incoming signal into the appropriate bandwidth, scales the signal, and sends the data to the digital controls and memory boards.

Participants

John Hines, NASA Ames Research Center
Christopher Miles, Sverdrup Technology, Inc.
Julie Schonfeld, NASA Ames Research Center

Status

Ames contacted the Team with a request for assistance in commercializing the Modular Sensor Conditioning System. RTI developed a Technology Opportunity Announcement which was used at Technology 2002 where the system was demonstrated. RTI also identified and contacted 28 companies identified as having a potential commercial interest in the system.

Motorola, Inc. has expressed interest in developing an Analog Data Module (ADM) based on the NASA system. The module will be used initially by NASA for physiologi-

cal measurements, but will be available for commercialization by Motorola. Daniel Winfield met with John Hines at Ames in May to discuss this opportunity.

The team scheduled and attended meetings at NASA Ames with two physiological monitoring companies on June 28 and 29, 1993. Both companies expressed interest in proposing projects to NASA. To date no proposals have been received.

Action

NASA will move forward with discussions with Motorola about the ADM project. The team will solicit input from the physiological monitoring companies to define specifications for commercial use of the ADM. This input may insure the ADM will meet requirements of the physiological monitoring market.

PROBLEM TITLE: Powder Curtain Prepreg Process

SOURCE OF PROBLEM: Langley Research Center

RTI TEAM PERSONNEL: Stephen Lehrman

Background

Thermoplastic composites offer the potential of more attractive mechanical properties at elevated temperatures than do other materials. The primary concern in achieving this potential has been the difficulty experienced in combining thermoplastics with continuous fiber tows to produce a composite prepreg material.

Many previous methods of applying polymer matrices to filamentary materials to produce composite prepregs have been attempted. These methods include slurry coating, coating from solvent based matrices, film coating and calendaring. The primary problem with most of these methods is the non-uniform distribution of the polymer materials through the filamentary materials. A second problem associated with these methods is the removal of certain species of carrier material in the polymer matrix at subsequent processing steps.

NASA Technology

NASA Langley Research Center has developed and patented a process for the uniform application of polymer powder resins to a filamentary tow in a continuous process to form a uniform composite prepreg. The patented technology involves an improved method for spreading the fiber tow and impregnating the tow with resin via a fluidized bed process to produce a uniform prepreg material. Advantages of this system over current methods are the elimination of the use of solvents and the predictable, uniform prepreg materials produced.

Langley Research Center has built a prepreg machine able to produce 12000 linear feet per day of single tow (1/8 inch) prepreg. The equipment can be modified to handle a multiple tow system. Almost any resin system supplied in powder form can be used.

Langley Research Center requested RTI's assistance in evaluating the commercial market for the equipment. RTI performed the evaluation and identified sixteen companies that may be interested in licensing the patent or co-sponsoring further development.

Participants

- Bob Baucom, NASA Langley Research Center

Status

As reported in the last RTI Quarterly report, the Application Team mailed Commercial Opportunity Program brochures on the powder curtain prepreg process to over 30 companies. Two companies, Polymer Composites Inc. of Minnesota and Electrostatic Technologies of Massachusetts, submitted acceptable letters of interest and statements of qualifications. These two companies were individually invited to meet with the Langley inventors.

Both companies visited Langley. They met with Mr. Baucom and were given information on submitting a technology transfer and commercialization proposal to Langley.

Action

The Applications Team and the Langley TU Office are coordinating discussions with Polymer Composites and Electrostatic Technologies. The purpose of the discussion is to assure that the companies are on-schedule with their commercialization proposals.

PROBLEM TITLE: Smart Sensing Technology
Predictive Response Method

SOURCE OF PROBLEM: Technology Development Program
John C. Stennis Space Center (SSC)

RTI TEAM PERSONNEL: Molly O'Donovan Dix

Background

At the request of Mark Mick, Technology Utilization Program Manager at SSC, RTI has assisted SSC in commercialization of the smart sensing technology and the predictive response algorithm it employs. A Fugitive Gas Detection System was developed by engineers at Sverdrup Technologies (SvT) for NASA. The predictive algorithm, which is the basis of the system, was developed to attain a rapid and accurate response from the best commercially available hydrogen sensor. SSC recognized several potential commercial applications for the algorithm, as well as the commercial value of the complete Fugitive Gas Detection System. Specifically, any innately slow sensor that provides a step output can utilize the predictive method to increase the sensor's speed of response. Potential applications include detection of gases other than hydrogen and digital electronic thermometers for humans and animals.

NASA Technology

The primary benefit of the SSC technology over commercially available products is the combination of attributes it provides. No commercial sensors were found which could provide the speed of response, rugged nature, accuracy and reliability for which the SSC system was designed. The Fugitive Gas Detection System is a complete management system with advanced display characteristics. The menu-driven system provides facility schematics for quick location of leaks and can be used for system calibration and maintenance.

Participants

- William L. Nail, Sverdrup Technologies
- Thomas L. Koger, Sverdrup Technologies
- Vivien Cambridge, Sverdrup Technologies

Status

SSC contacted the Team with a request for a market assessment and a recommendation on how to pursue commercialization of the predictive method. RTI reviewed the material presented by SSC and contacted sensor experts. RTI presented SSC with the information gathered during the market research and requested clarification on the patent status before continuing.

Following review of the market research by SSC, both RTI and SSC agree that commercialization should be pursued without a patent and that a patent should be applied for if a commercial partner and a specific application are identified.

RTI developed three Technology Opportunity Sheets to aid in contacting potential commercial partners. The first sheet identified the Fugitive Gas Detection System and the predictive method it employs, the second was tailored to companies interested in application of the algorithm to digital electronic thermometers and the third was a general description of the predictive method as it could be applied to numerous sensor applications. The Technology Opportunity Sheets were used by SSC and RTI to discuss the Smart Sensor Technology with prospective partners. The sheets were also used at Technology 2002.

RTI identified and contacted IVAC, a major medical products company, as a potential partner to commercialize the SSC algorithm as part of an electronic thermometer. Conversations have been in process with IVAC since October 1992. In early March a Nondisclosure Agreement was signed between IVAC and NASA. Technical review of the application by SSC and IVAC resulted in a desire by both parties to continue forward with the application of the SSC predictive response algorithm to the IVAC electronic thermometer. The team scheduled and attended a meeting at IVAC with SSC on June 30, 1993. The meeting resulted in the definition of a Phase I project to develop a proof of concept system. Specifically, this system must:

- A) respond (in mouth) in less than 10 seconds
- B) utilize IVAC's temperature probe and cover
- C) have a clinical accuracy equal to the existing system
- D) utilize a PC-based, commercially available data acquisition system
- E) result in a design capable of being converted to producible product

Action

IVAC must provide SSC both market and technical background information by July 9. NASA must develop a proposal for internal NASA approval by the end of July.

PROBLEM TITLE: Ultrasound Displacement Amplitude Measurement
SOURCE OF PROBLEM: Technology Utilization Office, Langley Research Center
RTI PERSONNEL: Molly O'Donovan Dix

Background

With expansion of the use of diagnostic ultrasound in recent years, there has been growing concern over the safety of ultrasound exposure, particularly with regard to the exposure of the fetus in utero. There is a good deal of research on the bio-effects of ultrasound and the development of reliable techniques to measure acoustic output from clinical diagnostic ultrasound equipment. The Food and Drug Administration (FDA) is promulgating new regulations to cover ultrasound equipment, and a new voluntary performance standard is being developed jointly by the National Electrical Manufacturers Association (NEMA) and the American Institute for Ultrasound in Medicine (AIUM). In the fall of 1989, FDA included their need in their draft document entitled *Research Agenda for the 1990s*.

Current measurement techniques use hydrophones constructed by polyvinylidene fluoride (PVDF) piezoelectric polymer. A response of hydrophones above 15 MHz is highly dependent on the nature of construction and film thickness, as well as associated preamplifier circuitry. Other factors that can affect measurement accuracy are the condition of the water medium, preamplifier dynamic range limitations, presence of shock fronts due to finite amplitude distortion, and spatial averaging due to the finite size of hydrophones. For these reasons, hydrophones must be calibrated to an NBS reference standard.

A technique to make accurately and reliably absolute measurement of ultrasound intensities is needed. The successful techniques must have a bandwidth of at least 50 MHz and have a focal diameter of approximately 1 mm.

NASA Technology

NASA LaRC physicists have developed a measurement system based on the LaRC-developed electrostatic acoustic transducer (U.S. Patent No. 4,080,960). The device is inherently insensitive to the phase on the acoustic wavefront, has broad-band response, and is capable of following the envelope of typical diagnostic imaging pulses. An accuracy of better than 2.3 to 4 percent is reported in the range of 0.4 to 15 MHz.

Participants

- Tom Yost, NASA LaRC

Status

NASA LaRC has completed the prototype instrument and method for absolute measurement. The RTI Team assisted early efforts by providing pertinent literature, establishing contact with NEMA and AIUM, and evaluating the commercial potential. In 1991 RTI also supplied details on the electrostatic acoustic transducer and on the proposed project to FDA, NEMA, and AIUM.

In 1992 RTI's activities included contacting the National Institute of Standards and Technology (NIST), FDA Center for Devices and Radiological Health and AIUM. From each contact we requested technical review of the prototype's results as presented in a pre-print article by W.T. Yost. We have communicated these results to LaRC and developed a commercialization strategy in conjunction with LaRC.

In 1993 RTI developed a Technology Opportunity Announcement which describes the technology and the commercialization opportunity. This opportunity sheet was sent to over 40 companies targeted as potential commercial partners. Six companies have expressed interest in the technology.

Action

A commercialization workshop is planned for October in conjunction with the Langley Open House.

6.0 ADD-ON TASK STATUS

This section presents the status of tasks added to the basic contract NASW-4367. The following add-on tasks were completed prior to this reporting period:

- **TASK 1: AdaNet Program Support**
- **TASK 2: CAD/CAM for Custom Orthopedic Shoes**
- **TASK 3: Optimization of the Parameters of the Rotating Reactor**
- **TASK 4: JSC Outreach Program**

The following tasks were active during the reporting period and are discussed in this section.

- **TASK 5: Spinoff Technology Application Retrieval System (STARS)**
- **TASK 6: Planning and Analytical Support to NASA for the National Technology Transfer Center Program Development**
- **TASK 7: Technology Transfer and Commercialization Assistance to the Kennedy Space Center**
- **TASK 8: Outreach Materials and Activities to Promote NASA Applications Engineering and the Technology Transfer Process**

Task 5: Spinoff Technology Application Retrieval System (STARS)

Task Leader: Ronnie Lashaw
Start Date: November 1991
Completion: September 1993

Background

NASA's Office of Commercial Programs initiated a request for RTI to develop a prototype, database system for the storage and retrieval of NASA Technology Spinoffs information. The basis for these Spinoffs is found in the Spinoff magazine. The name for this system has been designated as STARS (Spinoff Technology Application Retrieval System).

Objectives

The purpose of this task is to support NASA Headquarters Office of Commercial Programs in meeting the following objectives: 1) providing the public with a friendly, intuitive, and useful method for retrieving information about the secondary benefits of NASA Technology, and 2) providing NASA administrative personnel with a tool for responding to inquiries, preparing reports and speeches, and providing educational outreach material concerning NASA Technology Spinoffs. In this effort, RTI will work with NASA Headquarters to specify the requirements for the STARS system, both hardware and software. RTI will generate various prototype designs for review by NASA and will assist NASA in determining the best configuration of hardware and software for the system.

Status

RTI has completed all STARS development activities funded under this add-on task with the exception of the benefits analysis being performed by Chapman Research Group. Several hardware and software prototypes were designed, generated and tested. STARS has been converted from a database-only to a multimedia database supporting still images and audio/video input from VCR and/or laser disc players.

RTI has awarded a subcontract to Chapman Research Group in Denver, Colorado to analyze and update spinoff benefits for Spinoffs during 1987-91. Work performed during this period has included establishing the subcontract, developing a simple database

storage mechanism for benefits capturing, and Chapman beginning the research and analysis.

NASA Marshall has expressed interest in obtaining STARS for their Space and Rocket Center, but does not have sufficient funds to purchase the required equipment. NASA Kennedy has acquired a desktop version of STARS for the Technology Utilization Office. Other NASA Centers are expressing some interest in STARS.

A letter estimate has been forwarded to NASA HQ proposing to provide maintenance support of the installed base of the STARS application and to improve performance and functionality as specified by NASA HQ. Areas to be addressed include: congressional districts, keywords, 1992 Spinoffs, performance Critical Technology support, and software updates. The expected amount of support needed is \$50,000.

STARS has received widespread exposure at various national and regional meetings and has been installed at various locations for both NASA and public use. The following page provides a summary of STARS development and demonstration.

Spinoff Technology Application Retrieval System (STARS)

A multimedia, relational database management information system designed to meet the following objectives:

- 1) Provide the public with a friendly, intuitive, and useful method for retrieving information about the secondary benefits of NASA Technology, and
- 2) Provide NASA Administrative personnel with a tool for responding to inquiries, preparing reports and speeches, and providing educational outreach material concerning NASA Technology Spinoffs.

Presentations - made & scheduled

NASA Administrator - Washington, DC 1991
Technology 2001 - San Jose, California 1991
National Technology Initiative Conference - Boston, Massachusetts 1992
National Technology Initiative Conference - Austin, Texas 1992
National Technology Initiative Conference - Orlando, Florida 1992
National Technology Initiative Conference - Pasadena, California 1992
National Technology Initiative Conference - Raleigh, North Carolina 1992
National Technology Initiative Conference - Cleveland, Ohio 1992
1992 Space Symposium - US Space Foundation
International Video Science Consortium - Toronto, Canada 1992
National Challenger Center Office - Alexandria, Virginia 1992
NASA Headquarters to the Automated Resources Management Council (ARMC), Code C and other
NASA Codes - Washington, DC 1992
NASA Town Meeting - Raleigh, North Carolina 1992
NASA Town Meeting - Hartford, Connecticut 1992
NASA Town Meeting - Indianapolis, Indiana 1992
NASA Town Meeting - Los Angeles, California 1992
NASA Town Meeting - Tampa Bay, Florida 1992
NASA Town Meeting - Seattle, Washington 1992
National Technology Initiative Conference - Baltimore, Maryland 1992
Technology 2002 - Baltimore, Maryland 1992

Installations - completed

Virginia Air and Space Center - Hampton, Virginia 1992
NASA Headquarters - Office of Commercial Programs 1992
NASA Goddard Space Flight Center's Visitor Center - Greenbelt, Maryland 1992

Installations - discussions

Space Port USA - Orlando, Florida
NASA Kennedy Space Center
Challenger Center - Charlotte, North Carolina
Museum of History and Science - Louisville, Kentucky
North Carolina Museum of Life & Science - Durham, North Carolina
NASA Marshall Space Flight Center

Task 6: Planning and Analytical Support to NASA for the National Technology Transfer Center Program Development

Task Leader: Doris Rouse
Start Date: November 1991
Completion: September 1993

The purpose of this task is to provide selected planning and analytical activities in support of the NASA program development and management of the National Technology Transfer Center (NTTC). RTI will assist NASA and the NTTC in the development and refinement of cost-effective approaches for NTTC in its role of serving as a technology transfer link between industry and federal agencies. This support will include periodic analysis of NTTC program plans and reports and providing planning recommendations.

Status

RTI support to NASA HQ's Program planning and analysis of the National Technology Transfer Center activities in the reporting period has been:

- Completed classification of NASA Spinoffs by Critical Technology area.
- Participated in planning session at NASA HQ for technology transfer training initiative.

Action

- Assist NTTC in development of formats for reports to NASA.
- Provide input to NTTC on key considerations and software approaches for training programs for Field Center staff.
- Continue assistance to NASA HQ in planning activities.

Task 7: Technology Transfer and Commercialization Assistance to the Kennedy Space Center

Task Leader: Doris Rouse
Start Date: January 1992
Completion: September 1993

Background

This task is to provide a focused effort at the Kennedy Space Center to achieve expanded results in accomplishing two objectives: (1) developing agreements for joint participation in the technology transfer process and (2) providing a closer link to Kennedy technologists to identify new technologies with potential for transfer to the user community. RTI will assist KSC in developing linkages with external organizations and prepare draft agreements. RTI will also assist in review of technical progress in KSC technology development programs to ferret out new advances in technology that may be transferrable to the private sector. Finally, RTI will assist in assuring that new technology is incorporated into the KSC Technology Utilization Office records for quick access and processing for potential technology transfer purposes.

Status

The support to the NASA Technology Transfer Program at the Kennedy Space Center (KSC) consisting mainly of managerial, technical and administrative assistance in transferring technology, includes the following activities for the April-June 1993 quarter.

- Identified and evaluated ten KSC technologies having potential for commercialization. These technologies were also included in the TRP proposal to ARPA on the TRDA/NASA-KSC Dual-Use Technology Partnership.
- Assisted TRDA in preparing a TRP proposal to ARPA on the TRDA/NASA-KSC Dual-Use Technology Partnership.
- Prepared a Space Act Agreement between the State of Florida and KASA-KSC in regard to technology transfer. The agreement was staffed to the appropriate KSC and Florida organizations.

- In regard to new technology reporting and contract data, the following activities were accomplished:
 - 11 reportable items received and processed
 - 17 reportable items screened and rejected
 - 27 items evaluated
 - 6 items processed for publication
 - 16 TSPs forward for preparation
 - 88 inquiries answered
 - 5 problem statements evaluated
 - 5 new contracts established for monitoring
 - 9 certifications of compliance were produced
- 36 abstracts were submitted to Headquarters in response to the Technology 2003 Call for Papers.

Task 8: Outreach Materials and Activities to Promote NASA Applications Engineering and the Technology Transfer Process

Task Leader: Michael Hackett
Start Date: January 1992
Completion: September 1993

Background

This task is to develop outreach materials and activities to enhance applications linkages with industry and other user groups and develop effective means for addressing opportunities identified. Materials will be used for conferences, workshops, corporate interactions, etc. Activities will include preparation of slides and written materials describing the NASA Technology Transfer Program; maintenance of a visual resource library; and assistance to NASA in outreach activities.

Status

The following activities were completed during the April-June period.

- Processed, categorized and reviewed all abstracts submitted in response to the Call for Papers for Technology 2003. Approximately 320 abstracts in all were received covering 15 technical categories.
- Working with Len Ault from NASA and Joe Pramberger from Associated Business Publications, finalized the selection of papers to be presented, based on the ratings by the panels set up to judge each technical group of abstracts. A total of 100 papers were selected for presentation.
- Working with Trade Show Manager Wendy Janiel (of the TU Foundation and ABP), redeveloped all instructional materials, including any forms, regarding papers and presentations to be issued to all authors/speakers. Set things up for the distribution of the above materials and letters in mid-July.
- Since the number of technical presentations was cut back by 20 this year, worked with Len Ault in laying the groundwork to establish other forums for the presentation/demonstration of other noteworthy new technologies that would not be presented in the technical sessions. The emphasis was on better utilizing the strong media

presence at these shows to get the word out about Federal technology. Specific plans will be developed during the month of July.

- Manned the NASA Technology Transfer Exhibit booth at the Commercial Space Expo, April 13-14 in Colorado Springs, CO (held in conjunction with the 9th Annual Space Symposium); at IndustryTech '93, May 5-7 in Kansas City, MO; at the Technology Exposition: Yesterday, Today and Tomorrow, May 26-27 in Wallingford, CT; and at TechNet '93 (AFCEA's National Conference), June 8-10 in Washington, DC.

7.0 TRAVEL

April 4-7, 1993: Dan Winfield participated in the NASA Technology Transfer Network Conference in South Lake Tahoe, NV.

April 19, 1993: Gary Hughes met with the National Environmental Technology Applications Corporation (NETAC) in Pittsburgh. The objective of this meeting was to learn more about the technology transfer process and the environmental management industry.

April 19-21, 1993: Dan Winfield and Gary Hughes attended the Spring meeting of the Federal Laboratory Consortium in Pittsburgh, PA.

April 20, 1993: Gary Hughes met with the Air & Waste Management Association in Pittsburgh. This meeting was held to explore the possibilities of developing problem statements through this national organization.

April 28, 1993: Doris Rouse chaired a 30th Space Congress session entitled "30 Years Of Progress, Spinoffs From Space Technology" in Cocoa Beach, FL. Dr. Rouse also presented a paper entitled "Dividends from Space: How NASA Technology Has Provided A Competitive Advantage for Industry."

April 28, 1993: S.A. Lehrman participated in the American Society of Mechanical Engineers/National Laboratory Technology Transfer Committee meeting in Washington, DC. Mr. Lehrman arranged for NASA to write a technology transfer article for publication in the August, 1993 issue of ASME News.

May 3, 1993: Gary Hughes met with the leadership of the Center for Composite Materials, University of Delaware, Wilmington, DE. The Center for Composite Materials is serving as a source for a series of problem statements dealing with priority problems faced by the advanced materials industry.

May 4, 1993: Gary Hughes met with the Executive Director of the Hazardous Materials Control Research Institute, Greenbelt, MD. This organization will serve as a good connection to the hazardous waste treatment industrial community.

May 5, 1993: Gary Hughes organized several meetings with researchers and the Technology Utilization Office at the National Aeronautics and Space Administration Langley Research Center, Hampton, VA. The primary area of interest for this visit was nondestructive evaluation techniques for composite materials. A Center meeting which covered the status and future work on the carbon/carbon piston was also attended.

May 18-20, 1993: Dan Winfield travelled to Bethesda, MD to chair the NCI-NASA Workshop on Digital Mammography Technologies.

May 19-21, 1993: Doris Rouse travelled to Johnson Space Center, Houston, TX, to participate in the first meeting of the JSC Technology Commercialization Working Group including IC² and the Mid Continent RTTC.

April 23, 1993: Dan Winfield travelled to Washington, DC to (1) meet with NASA HQ on dual-use technologies and (2) meet with the National Cancer Institute and the National Electrical Manufacturers Association concerning the planned Digital Mammography Workshop.

May 25-28, 1993: Dan Winfield participated in a meeting of the NASA Operations Intercenter Work Group and gave a briefing on our technology transfer support. While at NASA Ames, Mr. Winfield also met with John Hines to prepare for meetings with companies interested in collaborating with NASA on medical measurement systems. While in California, Mr. Winfield also met with Stephen Gomes of Amtech to discuss areas for cooperation.

June 1-2, 1993: Doris Rouse made a presentation to the Primary Targeted to Secondary Targeted Technology Transfer Process Improvement Team in Washington, DC.

June 10, 1993: Gary Hughes attended a meeting with the Risk Reduction Engineering Laboratory of the United States Environmental Protection Agency, Cincinnati, OH. Representatives from Lewis Research Center presented information on an ion exchange material for removing heavy metals from industrial waste water.

June 10, 1993: Gary Hughes met with the University of Cincinnati Space Engineering Research Center. Several technologies, including an infrared technique for joining materials, appear to be candidates for commercialization.

June 14-16, 1993: Gary Hughes attended the Air & Waste Management Association Annual Meeting in Denver. He made contacts for future commercialization opportunities and for sources of environmentally related problem statements. Mr. Hughes also made a brief presentation to the hazardous waste committee.

June 24, 1993: Doris Rouse and Gary Hughes travelled to Langley Research Center to make a presentation to the Antenna and Microwave Research Branch with Joe Mathis and Frank Farmer of the Langley Technology Utilization Office. Technology transfer concepts were discussed to assist this branch with documenting past activity and to plan for more effective, proactive technology transfer processes in the future. The discussion led to an agreement that the RTI Team would assist AMRB in its technology transfer plans.

June 28, 1993: S.A. Lehrman and S. Mangum met with Mr. David Thompson, Chief, Economic and Commercial Crime Division, Victoria Police Department, Australia at Goddard Space Flight Center. The meeting was hosted by Don Vargo and attended by Ray Gilbert and Kevin Jackson. The purpose of the meeting was to discuss applications of NASA technology to combat computer crime.

June 28-29, 1993: Daniel Winfield and Molly O'Donovan Dix scheduled and attended meetings at NASA Ames with potential commercialization partners for the Ames Modular Sensor Conditioning System. Two separate meetings were held with two physiological monitoring companies to demonstrate and discuss the Ames' system. Both companies expressed interest in working with NASA.

June 30, 1993: Daniel Winfield and Molly O'Donovan Dix participated in a meeting at IVAC Corporation to discuss application of the Stennis predictive response algorithm to the IVAC electronic thermometer. The meeting resulted in the definition of a Phase I project to develop a proof-of-concept system.

June 30, 1993: S.A. Lehrman participated in the Lewis Research Center Process Improvement Team meeting on Secondary Technology Transfer. The meeting was held in Cleveland, OH and chaired by Bruce Banks. While at LeRC, Mr. Lehrman met with Tom Glasgow and Dr. Arnan Chait of the Computational Materials Lab to discuss their technology transfer activities.

APPENDIX A

NASA Technology Applications Team Staff

APPENDIX A: NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF		
STAFF MEMBER	BACKGROUND	PROJECT RESPONSIBILITY
Doris J. Rouse, Ph.D.	<u>B.A., Chemistry/Ph.D. Physiology.</u> Sixteen years in NASA program. Five years research and management in industry.	Project Director: Assignment of project tasks to staff and consultants. Program Planning, review for all Team projects.
Daniel L. Winfield, M.S.	<u>B.S., Engineering Analysis/M.S., Biomedical Engineering</u> Eight years in NASA Technology Utilization Program. Eight years experience in product development and manufacturing in the medical device industry.	Management of biomedical and rehabilitation projects. Areas of specialization include ophthalmology and orthopedics.
Stephen A. Lehrman, M.S.	<u>B.S., Mechanical Engineering/M.S., Mechanical Engineering.</u> Six years in NASA Technology Utilization program. Thirteen years experience in mechanical design and analysis for manufacturing industries.	Coordination of manufacturing and Industrial projects. Areas of specialization include material science, mechanical engineering, precision engineering and optics.

**APPENDIX A:
NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF**

STAFF MEMBER	BACKGROUND	PROJECT RESPONSIBILITY
<p>Stephen D. Mangum, M.P.A.</p>	<p><u>B.S., Political Science/M.P.A., Master of Public Administration.</u></p> <p>Serving fifth year in NASA Technology Utilization Program. Experience at NASA Headquarters' International Relations Division assessing the impact of the export of technology on U.S. industry and commercial competitiveness.</p>	<p>Serves as Program Analyst. Areas of concentration include organizational management, budgeting and finance, and database management.</p> <p>Assists project managers in background, marketing/industry studies and development of cofunding opportunities. Also, assists in the management of Application Projects in the Public Service area.</p>
<p>Dean H. Hering, M.S.</p>	<p><u>B.S., Electrical Engineering/M.S. Electrical and Computer Engineering.</u></p> <p>Three years serving NASA Technology Utilization Program. Over six years experience in electrical engineering, digital design, neural networks, and Artificial Intelligence.</p>	<p>Coordination of manufacturing and industrial projects.</p> <p>Areas of specialization include electrical engineering, digital design, and Artificial Intelligence.</p>

**APPENDIX A:
NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF**

STAFF MEMBER	BACKGROUND	PROJECT RESPONSIBILITY
<p align="center">C. Gary Hughes, P.E.</p>	<p><u>B.S., Aeronautical and Astronautical Engineering / M.S., Aeronautical and Astronautical Engineering.</u></p> <p>Joined the NASA Technology Applications Team staff in 1992 after 25 years experience in Industry.</p> <p>Broad experience base includes engineering and management in manufacturing, electric power plants, aerospace, consulting, market research and marketing.</p>	<p>Coordination of manufacturing and Industrial projects.</p> <p>Areas of specialization include, mechanical and structural engineering, waste and environmental management, materials, and aeronautics.</p>
<p align="center">Molly O'Donovan Dix</p>	<p><u>B.S., Mechanical Engineering</u></p> <p>Joined the Technology Applications Team in 1992 with three years experience in engineering services. Performed engineering assessments and recommendations for industrial and commercial electric energy conservation.</p>	<p>Provides support to other Applications Team staff by researching background information on new technologies and new project opportunities.</p> <p>Provides technical writing for problem statements, technology prospectus, and spinoff summaries.</p>

APPENDIX B

**Spinoff! Sheets and Technology Opportunity Announcements
Developed by RTI April - June 1993**



NASA TECHNOLOGY TRANSFER

Commercial Applications of Aerospace Technology

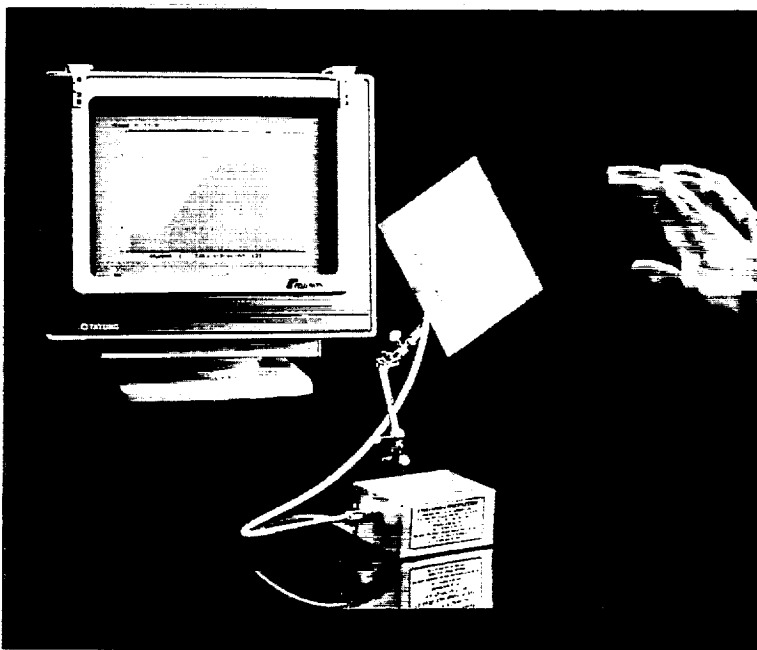
Capaciflector

Capacitive Reflector for Proximity Sensing

The role of robotics continues to develop as robots become integral elements of many manufacturing environments and functions. However, the potential for collision when integrating robots into manufacturing areas or alongside humans creates a significant safety problem. To ensure the safety of astronauts working with robots in space, NASA developed the Capaciflector, a proximity-sensing skin that attaches to the robotic manipulator. The Capaciflector can accurately detect objects and thus enables robots to avoid collisions. The Capaciflector technology, which can be applied to numerous proximity-sensing applications, is now commercially available from Computer Application Systems, Inc. (CASI) as a result of a licensing agreement with NASA. This Spinoff sheet describes NASA's Capaciflector technology and is presented as an example of a successful transfer of NASA technology to commercial application. If you are interested in the Capaciflector technology or the NASA Technology Transfer program, please contact the appropriate individual identified on the back of this page.

The Technology

In exploring the possible use of a capacitive array for collision avoidance, NASA found that the sensor range of existing systems was typically one inch, not sensitive enough to detect and react to an object. To increase the range and sensitivity of existing capacitive sensors, researchers at NASA's Goddard Space Flight Center developed the Capaciflector, a capacitive-sensing element backed by an active reflector. The reflector element acts as a shield to reflect field lines away from the grounded manipulator to which the sensor is attached.



The Capaciflector is able to dramatically increase the range and sensitivity of the capacitive sensor by shielding the sensor from the underlying ground of the manipulator and directing the electric field toward the object being sensed. This configuration reduces the standoff required

by the sensor, enabling the sensor to be incidental to the robot arm. The Capaciflector, when integrated with a robot controller, provides enough sensitivity for robotic path planning and control for most applications that include human interaction.

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CAPACITIVE SENSOR PRINCIPLES

Figure 1

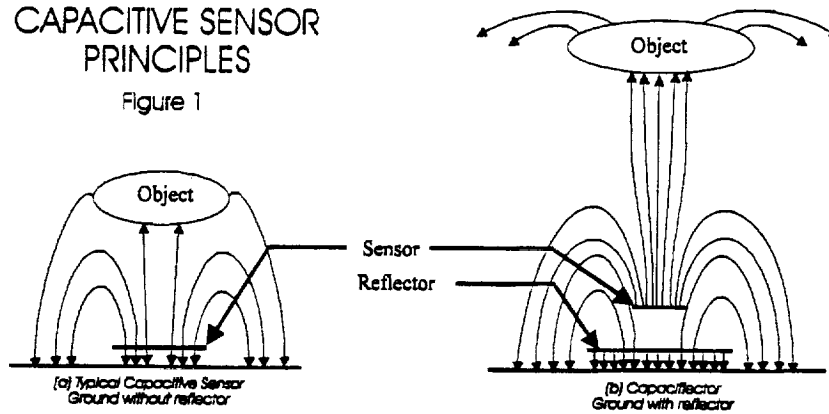


Figure 1(a) shows a typical capacitive sensor with a reduced range resulting from coupling with the manipulator (ground). With the Capaciflector, Figure 1(b), the field lines from the sensor are prevented from returning directly to ground. This shielding reduces the capacitive coupling between the sensor and manipulator and increases the effective sensor range.

Other Applications

The Capaciflector technology lends itself to:

- > process control;
- > proximity sensing and object avoidance;
- > capacity (volume) monitoring;
- > vibration monitoring and counting;
- > object monitoring, including speed, size, and shape determination; and
- > security and safety.

The Product

Capaciflector technology is now commercially available from Computer Application Systems, Inc. (CASI) as a result of a licensing agreement with NASA. CASI manufactures and sells the sensors for a diverse group of applications, including path definition and obstacle detection for a robotic tower climber and process control for manufacturing. The sensor can be built to various size, shape, range, and sensitivity specifications.

Technology Benefits

The Capaciflector offers these improvements:

- > Increased sensitivity and range;
- > Rugged, compact, noninvasive, and robust;
- > Omni-directional (no receiver required);
- > Flexible configuration (diverse applications);
- > Reduced sensor standoff that reduces the bulk of the sensor, and eliminates parameter reprogramming;
- > Economical - reduced costs resulting from reduced hardware, reduced mounting area, and reduced manipulator adaptation.

NASA's Involvement

The Capaciflector was developed by NASA to help robots "see" and avoid objects. The original prototype sensor was built and tested at NASA's Goddard Space Flight Center. NASA transferred the technology from Goddard to CASI under its Technology Transfer Program. This transfer was assisted by NASA's Technology Applications Team at Research Triangle Institute (RTI). RTI developed a detailed and comprehensive information package that enabled targeted companies to evaluate the Capaciflector technology based on technical and market descriptions. As a result of RTI's assistance, CASI obtained a nonexclusive license for the Capaciflector technology from NASA.

Contact

For more information on this product or technology, please contact Goddard Space Flight Center's Technology Utilization Office at:

Goddard Space Flight Center
Mail Code 702
Greenbelt, MD 20771
Attn: Nona Minnifield
301/286-8504
or:

Computer Applications Systems, Inc.
P.O. Box 251
Signal Mountain, TN 37377
Attn: Craig Harston
615/752-1787

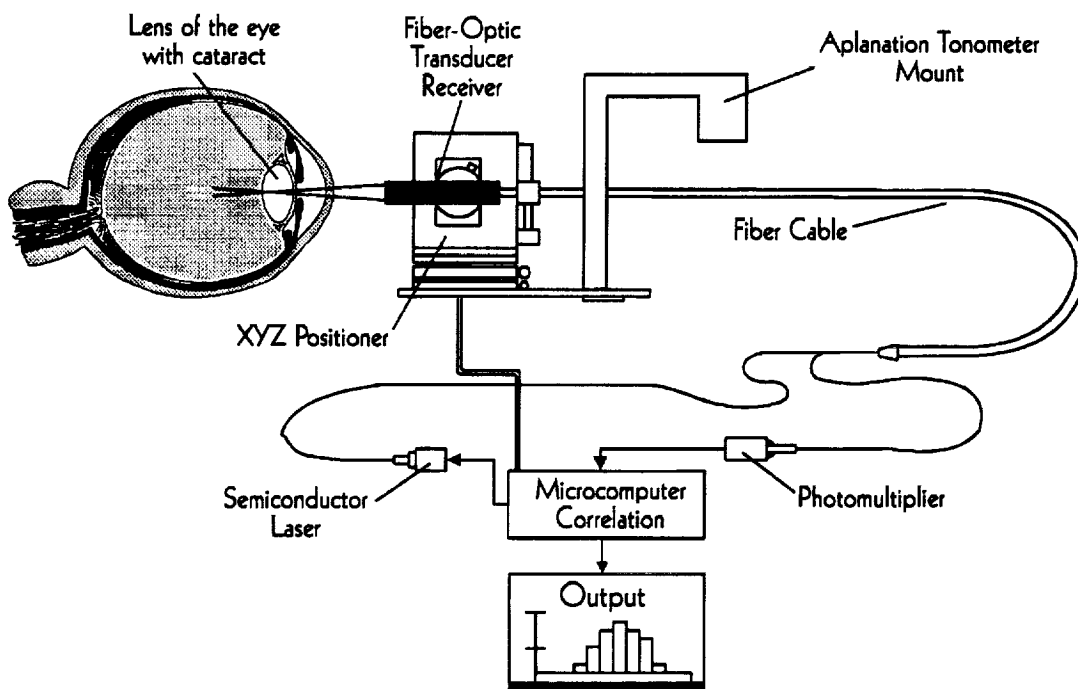


NASA TECHNOLOGY TRANSFER

Commercial Applications of Aerospace Technology

Fiber Optic Cataract Probe

The National Aeronautics and Space Administration seeks a partner to develop a commercial version of a fiber optic probe for early detection of cataracts. The device was invented by NASA Lewis Research Center and State University of New York at Stony Brook as a rugged and compact sensor for space microgravity experiments. The noninvasive probe measures cataractous changes in human eye lenses by using dynamic light scattering, a technique that probes and characterizes the dynamic behavior of fluid systems. The fiber optic probe is compact, rugged, safe, sensitive, and easily mounted onto existing clinical devices.



Product Profile

Cataracts form when the normally transparent lens of the eye becomes cloudy. Changes to the proteins in the lens of the eye indicate the development of a cataract. The current clinical diagnostic technique, which involves visual inspection of the lens through a slit-lamp, lacks the sensitivity to detect the small cellular and biochemical changes of early cataract formation. The NASA fiber optic probe, with its increased sensitivity, could quantify even early lens changes and provide a useful tool for studies of cataractogenesis. Other possible ophthalmic applications of this probe include characterization of collagen fibrils in the corneal stroma and of protein molecules in the anterior chamber.

The sensitivity of the fiber optic probe was demonstrated in limited laboratory studies of bovine eyes and in human eyes from 18 to 73 year old donors. As a mammalian eye lens ages, alpha-crystallin, a protein specific to the lens, is converted to higher molecular weight. As these molecules aggregate, they give rise to a cataract. Bovine studies clearly show the increase in alpha particle size as a cataract develops. Studies on human eyes with the fiber optic probe show an increase in the average hydrodynamic diameter of alpha-crystallin from 20 nm in a normal eye lens to 80 nm in a cataractous lens. The technique easily reveals significant changes in alpha particle size in 43 and 55 year old

Technology Opportunity

human lenses that clinically would have been judged to have only mild cataractous changes.

The Technology

The fiber optic probe uses dynamic light scattering (DLS) to perform noninvasive measurements of lens protein size, size distributions and molecular weight. While DLS has existed for many years, its commercial use was limited by elaborate instrumentation, bulk optics, and alignment problems. This new probe overcomes earlier limitations by incorporating advances in solid state electro-optics and lasers, and fiber optic DLS spectrometers. The new system requires no lenses, has no moving parts, does not need alignment, and is insensitive to vibrations. At less than 5 mm diameter, the probe is designed to be rugged, compact, and effective.

The probe consists of two optical fibers contained in the same cable assembly. One fiber transmits a Gaussian laser beam from its source to the scattering medium, the lens of the eye. The second fiber is positioned at an established backscatter angle to collect and relay the signal to a photon detector. The laser light is tightly focused onto the lens. This focus provides high power density in the scattering volume, ensures good signal to noise ratio, and negates effects of scattering influences from the cornea and anterior chamber.

The fiber optic probe and positioner are mounted onto a universal aplanation tonometer mounting assembly. This arrangement allows for precise positioning and location of the scattering volume in any substantially transparent region of the anterior segment of the eye. The design also assures that the beam divergence beyond the lens will reduce the chance of radiation damage to the retina. Processing and analysis can be performed on a PC platform using a single digital correlator board, thereby limiting exposure time of the laser and automating data analysis.

Safety

DLS measurements take between 30 seconds and 2 minutes per auto correlation. The damage threshold for retinal irradiance is 2 W/cm² for a 10-second exposure. Expected retinal irradiance from this system is less than 0.005 W/cm², three orders of magnitude below the damage threshold. The application of the fiber optic probe is procedurally similar to techniques familiar to ophthalmologists such as aplanation tonometry and ultrasonography. The procedure can be performed eas-

ily at a slit lamp under the installation of topical (drop) anesthesia with minimal patient discomfort. Eye movement is negated by having the patient direct vision in the contralateral eye on a fixation light.

Benefits

- **Compact**, less than 5 mm diameter
- **Rugged**, solid state electro-optics and lasers, no lenses, no moving parts
- **Safe**, minimal laser exposure & retinal irradiance
- **Effective**, high sensitivity, automated data analysis, easily mounted on standard ophthalmic equipment.

This new probe's primary value is its ability to detect and quantify early to moderate cataracts. Mechanisms initiating cataract formation are well understood, but the point at which cataractous formation becomes inevitable and irreversible remains to be identified. This technology could be used to evaluate the efficacy of cataract prevention and treatment research. Clinically, this procedure could monitor for very early cataractous side effects of chronic steroid therapy.

Technology Transfer Status

This technology opportunity is part of the NASA Technology Transfer Program. The Program seeks to stimulate development of non-aerospace commercial applications from NASA-developed technology. The NASA Lewis Research Center seeks a commercial partner to develop a clinical prototype, conduct clinical testing, and ultimately commercialize the fiber optic probe discussed in this sheet. The National Eye Institute has expressed interest in conducting multi-center clinical trials using the fiber optic probe upon completion of the initial clinical studies performed with a commercial partner.

Contact

If your company is interested in this fiber optic cataract probe, please contact:

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NASA TECHNOLOGY TRANSFER

Commercial Applications of Aerospace Technology

Ocular Screening

Low-Cost Vision Screening

Image processing and optics technologies developed by NASA provide the basis for a low cost, easy-to-use vision examination system manufactured by Vision Research Corporation of Birmingham, Alabama. The *Ocular Screening System (OSS-C)* is noninvasive, requires minimal subject cooperation, and completes a full patient screening in under a minute. These properties enable the system to simplify the detection of eye problems in infants and pre-school children. The screening system photographically records the reflective properties of the inner and outer parts of both eyes simultaneously. The images can then be compared to normal eyes for cases of nearsightedness, farsightedness, cataracts, and other ocular abnormalities. In cases of ocular alignment problems, one eye can be compared to the other using this system. Fully registered with the Food and Drug Administration, the technology is available from Vision Research Corporation under a license from NASA.



FIGURE 1 --

The OSS-C provides simple, reliable screening for eye defects. Because the system requires no communication from the patient, the OSS-C system can easily determine the ocular status of very young children. In the photo at left, the child's right eye shows a red disc characteristic of a normal retinal reflex; the dark coloration of the left eye's retinal bed indicates a defect, a cataract.

The Technology

The OSS-C uses a color photograph to test the human eye for refractive error and obstruction in the cornea or lens. The device photographically records the reflective properties of the inner and outer parts of both eyes simultaneously. The system's key element is a photorefractor consisting of a 35-millimeter camera, a telephoto lens, and an electronic flash. The

flash sends light into the subject's eyes which is reflected from the subject's retina back to the camera lens, producing a specialized image of the subject's eye. Nonuniformity in the coloration of these images indicates an ocular defect as illustrated in Figures 1 and 2. Abnormalities are identified by a trained observer's visual examination of the reflexes in the image.

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The Product

Designed for safe, convenient screening in both clinical and mass-screening environments, the OSS-C possesses greater sensitivity than the traditional eye chart. It is portable, rugged, requires little maintenance, and provides consistently interpretable results. Although recommended by pediatric ophthalmologists, regular screening of pre-school age children and infants for eye defects is not a widely instituted practice in the United States. OSS-C provides a simple, reliable, fast and relatively inexpensive tool which enables this valuable testing. An early program with KinderCare Corporation provided vision screening to children at many of their over one thousand KinderCare Learning centers in the United States and Canada.

Vision Research began marketing the OSS-C in mid-1991 and, within a year, pediatricians in 16 states were using the system. Additionally, a number of

civic and school organizations acquired the system, including several that concentrate on children with disabilities and special education needs; these children are typically difficult to screen by any other method and show a much higher percentage of eye problems than the general population. In 1992, about 50,000 children were screened by the OSS-C; some 4,000 of them showed problems significant enough to warrant professional attention.

NASA's Involvement

Initiated as a NASA-sponsored applications engineering project to meet a need for low-cost vision examination, the OSS-C incorporates NASA image processing and optics technology. John Richardson of the Marshall Space Flight Center and Joseph Kerr of Medical Sciences Corporation developed and patented this ocular screening system. The technology is now commercially available from Vision Research Corporation under an exclusive license from NASA.

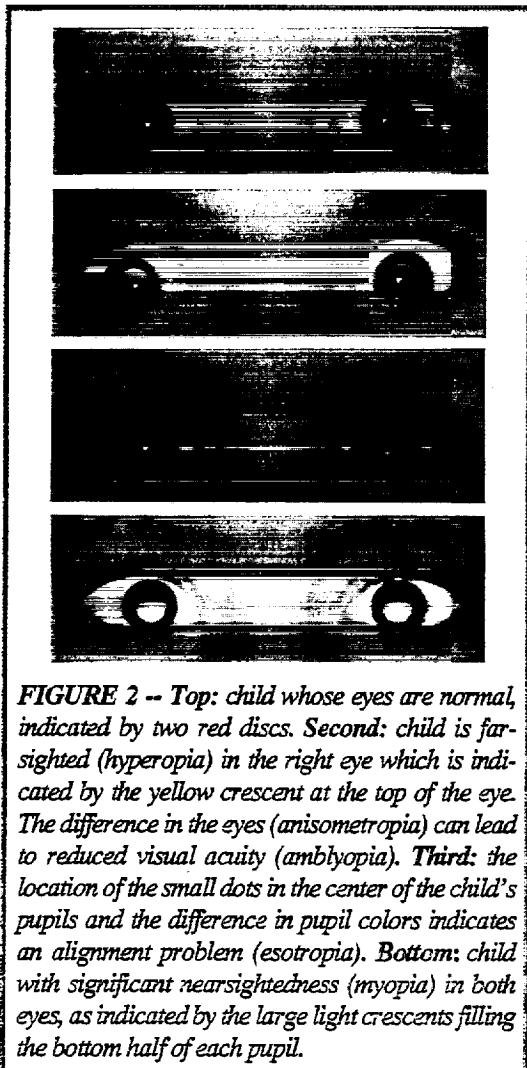
Technology Benefits

- > Provides simple, reliable, fast and inexpensive screening for eye defects;
- > Determines ocular status of children as young as six months;
- > Uses a non-invasive procedure requiring minimal cooperation and less than 30 seconds to perform; and
- > Detects irregularities related to the optical properties of the eye
 - *refractive errors*: nearsightedness, farsightedness, and astigmatism
 - *alignment errors*: conditions that indicate or lead to "lazy eye"
 - *obstructions or opacities*: such as cataracts.

Contact

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NASA TECHNOLOGY TRANSFER

Commercial Applications of Aerospace Technology

Virtual Reality Data Visualization Technology

The National Aeronautics and Space Administration (NASA) seeks to transfer into the commercial sector technology to visualize data with virtual reality (VR) capabilities. NASA and its partners offer for transfer computer software that can crop and clean digital images, describe a surface of a volume as polygons using a series of sequential digital images, then finally translate these surfaces as three-dimensional (3-D) stereo images. This technology has been used to create a series of programmed "fly throughs," allowing the observer to experience virtual reality during a tour through the human skull and heart. These "fly throughs" are also available for transfer to the commercial sector. The current research emphasizes creating a high resolution virtual reality simulator of a human body for educational purposes, but many other potential applications for this technology exist where complex 3-D structures are studied.

Studying 3-D images on a two-dimensional (2-D) computer screen can be compared to looking at fish through a glass-bottomed boat, whereas VR allows one to put on the scuba equipment and interact with the surroundings without getting wet. VR interface is intuitive and utilizes spatial and psychomotor abilities that are now constrained or reduced by the current 2-D terminals and keyboards.

Endowing medical students with an understanding of the human body poses some difficult challenges. One of the most difficult is to convey the 3-D nature of anatomical structures. Recently there has been a tremendous increase in interest in creating computer based human anatomic studies, including commercially available interactive educational software. No available software programs yet offer VR as a tool to study human anatomy. VR not only offers invaluable educational advantages in the study of human anatomy, but also in any other area where complex three-dimensional relationships need to be studied.

NASA Technology

NASA began work with VR to assist with astronaut training using models of the shuttle and space station at NASA's Johnson Space Center (JSC). Since the development of this model, NASA and its partners Lin-Com Corporation, the University of Texas Medical Branch at Galveston, and the Galveston Independent School District have teamed up to develop Virtual Visual Environment Display (VIVED) that provides a unique educational experience using VR technologies.



GOAL

Astronaut in Orbit

Virtual Reality technology provides a unique educational experience allowing the observer to travel through complex three dimensional objects.

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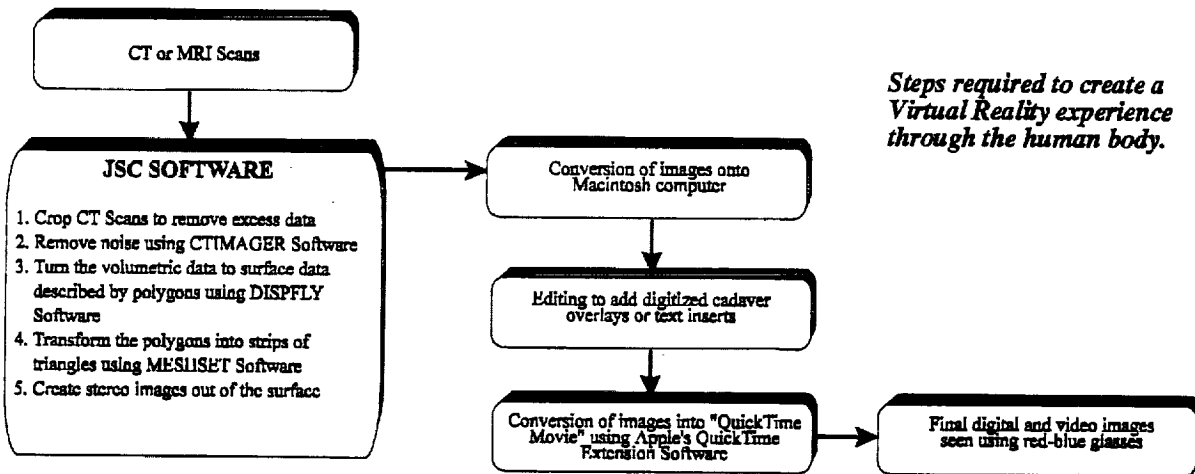
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ORIGINAL PAGE

BLACK AND WHITE PHOTOGRAPH



Technology Applications



A schematic describing the steps involved in creating a VR experience through the human body is presented on the back of this sheet. CT/MRI slices, which are 1.5 mm thick, are being used to create images of astounding resolution. The JSC software software, when run on the Silicon Graphics computer, makes it possible to turn these slices into 3-D volumetric images and movies of the observer "flying through" the body in a prescribed pattern.

The Product

The Macintosh computer was selected for viewing the final 3-D images because it is relatively affordable and is in widespread use in school systems. The end product of the virtual reality movie can be stored either on a hard drive or transferred onto video tape and viewed through red-blue glasses. Many other forms of multimedia can be incorporated into the finished product. A VR head-mounted display (HMD) or boom system can be used to view the final images. CD ROM or laser disc can also be used to store the final images. The computer can allow for interaction so that the user can "freeze" an image and query about what is seen. Audio can easily be added to allow for narration or music during sequence viewing.

Current limitations in data processing rates due to the high resolution of the body images prohibit the observer from "flying" through the human body at will; instead only the technology to create prescribed "fly-throughs" is currently available. Alternative hardware and software options are being explored to deal with this problem. With less data-intensive applications, i.e., with applications requiring less resolution, the technology is available for a full interactive virtual reality experience.

Applications

Applications for this technology include any area in which complex three-dimensional relationships must be understood, such as:

- Anatomy education
- Education for mechanics of all types
- Education for chemistry students
- Pathology studies for surgeons
- Simulation of plastic and reconstructive surgery
- Endoscopic training for surgeons

Technology Transfer Status

NASA seeks commercial applications that may require this new technology and a commercial partner to develop the technology for these applications. Transfer of the technology is being coordinated by NASA's Technology Applications Team at Research Triangle Institute as part of the NASA Technology Transfer Program. This program seeks to stimulate the use of NASA-developed technology in commercial applications.

Contact

If your company is interested in this Virtual Reality Data Visualization Technology and its application for preprogrammed virtual reality experience through the human skull and heart, please contact the NASA Technology Applications Team:

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