NASA

TECHNOLOGY APPLICATIONS TEAM

COMMERCIAL APPLICATIONS OF AEROSPACE TECHNOLOGY

ANNUAL REPORT

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1.0 INTRODUCTION

The Research Triangle Institute (RTI) is pleased to report the results of NASA contract NASW-4367, "Operation of a Technology Applications Team". Through a period of significant change within NASA, the RTI Team has maintained its focus on helping NASA establish partnerships with U.S. industry for dual use development and technology commercialization. Our emphasis has been on outcomes, such as licenses, industry partnerships and commercialization of technologies, that are important to NASA in its mission of contributing to the improved competitive position of U.S. industry. As shown in Table 1, the RTI Team has been successful in the development of NASA/industry partnerships and commercialization of NASA technologies.

RTI's ongoing commitment to quality and customer responsiveness has driven our staff to continuously improve our technology transfer methodologies to meet NASA's requirements. For example, RTI has emphasized the following areas:

- **Methodology For Technology Assessment And Marketing:** RTI has developed and implemented effective processes for assessing the commercial potential of NASA technologies. These processes resulted from an RTI study of best practices, hands-on experience, and extensive interaction with the NASA Field Centers to adapt to their specific needs.

- **Effective Marketing Strategies:** RTI surveyed industry technology managers to determine effective marketing tools and strategies. The Technology Opportunity Announcement format and content were developed as a result of this industry input. For technologies with a dynamic visual impact, RTI has developed a stand-alone demonstration diskette that was successful in developing industry interest in licensing the technology.

- **Responsiveness to NASA Requirements:** RTI listened to our customer (NASA) and designed our processes to conform with the internal procedures and resources at each NASA Field Center and the direction provided by NASA's *Agenda for Change*.

This report covers the activities of the Research Triangle Institute Technology Applications Team for the period 1 October 1993 through 31 December 1994. Mr. Len Ault, NASA Headquarters, was the Contracting Officer's Technical Representative. The work was performed in the RTI Center for Technology Applications under the direction of Dr. Doris J. Rouse. Other participants in the program were Ms. Molly Dix, Mr. Dean Hering, Mr. Gary Hughes, Mr. Stephen Lehrman, Mr. Stephen Mangum, Ms. Laura Schoppe, Mr. Daniel Winfield, Mr. Michael Hackett, and Ms. Nancy Court. RTI consultants participating during the reporting period were Dr. Charles Chiklis, Mr. Harry Watters, and Mr. Robert Wallace.

Table 1: The RTI Team's Technology Transfer Successes over the past 3 years

Technology	Participants	RTI Role / Outcome
Low Vision Enhancement System	SSC/Wilmer Eye Institute/Visionics Corp.	• Defined requirements via workshop • Conducted NASA site visits with Wilmer researchers • Drafted Space Act Agreement (SAA) • **Commercial product introduced**
Diamond-like Coated Sunglass Lenses	LeRC/Diamonex/Bausch & Lomb	• Conducted market survey • **Technology licensed, commercial product introduced**
Excimer Laser Angioplasty	JPL/Cedars-Sinai Medical Ctr./ Advanced Interventional Systems	• Wrote Problem Statement • **New company formed, commercial product introduced**
Capaciflector	GSFC/Computer Application Systems, Inc.	• Identified potential licensee • **Technology licensed & commercialized**
Flow Cytometry	JSC/American Cancer Society/ University of Miami/Ratcom, Inc.	• Defined problem, located NASA technology • Conducted workshop to validate need • Helped write grant application to ACS • **Dual use project, spinoff version commercialized**
Bladder Fullness Monitor	LaRC/Association for Retarded Citizens/Diagnostic Ultrasound, Inc.	• Wrote Problem Statement, located NASA technology • Helped write grant application to NIDRR • **Cooperative project, technology licensed, being commercialized**
Wireless Infrared Communications System	JSC/K&M Electronics	• Identified company for dual-use development • **Commercial product, dual-use project successful on shuttle mission**
Deformable Mirror Device Printer	JSC/Texas Instruments	• Assisted development of project plan • **Commercial product introduced**
Ultrasound Burn Depth Analysis	LaRC/Medical College of Virginia/ SupraMedical Corp.	• Conducted technology assessment • Identified clinical and industry partners • **Commercial product introduced**
Ground Processing Scheduling System	KSC/ARC/Red Pepper Software	• Assisted with technology briefing • **Copyright license signed, commercialization underway**
Contextual Alarm Management	JSC/SpaceLabs, Inc.	• Wrote Problem Statement • Located commercial partner • Helped write project plan and negotiate intellectual property terms • **SAA signed, project underway**
Optically Stimulated Electron Emission for Printed Circuit Board Inspection	LaRC/National Center for Manufacturing Sciences (NCMS)/Texas Instruments/ AT&T	• Identified match between NCMS need and NASA technology • Helped define scope for feasibility study • **SAA signed, NCMS funding NASA, project underway**
Early Language Intervention System	JSC/Laureate Learning Systems, Inc.	• Wrote Problem Statement and located NASA technology • Helped write project plan • **SAA signed, project underway**

Table 1 (Cont.)

Technology	Participants	RTI Role / Outcome
Self-nulling Eddy Current Probe	LaRC/Krautkramer Branson	• Helped write brochure for Commercial Opportunity Workshop • Identified companies • Helped NASA assess companies • **Agreement signed, commercialization initiated**
Digital Mammography	HQ/National Cancer Institute JPL/General Electric Co. JPL/Nanoptics, Inc.	• Initiated contact and wrote agreement with NCI • Wrote Problem Statement, located technologies • Conducted workshop to evaluate solutions • Helped draft interagency solicitation • Helped secure Code UL and CD funds • **Agreement signed, three projects (2 NASA) funded**
Convolver for Real-time Signal and Image Processing (CRISP)	LaRC/Westdyn LaRC/BBB Amdata	• Helped prepare brochure for commercial opportunity workshop • Assisted in Commercial Opportunity Workshop, followed up with companies • **Cooperative agreements signed with two companies**
Medical Oxygen Concentrator	KSC/Florida Solar Energy Center/ Healthdyne Technologies, Inc.	• Developed and distributed Commercial Opportunity Announcement (COA) • Assisted in negotiations with potential partners • Helped draft project plan • **Cooperative agreement signed, project underway**
Predictive Sensor Algorithm	SSC/IVAC Corp.	• Used COA to locate company • Helped assess technology fit and develop project plan • **SAA signed, project successful, commercialization underway**
Colorless, Low Dielectric Polyimides	LaRC/ChemDev, Inc./ L'Garde	• Assessed markets • Wrote Commercialization Plan • Prepared COA, marketed technology • **Two SAAs executed with companies**
Electrically Conductive Polymer Coatings	KSC/Los Alamos National Lab/Akzo Chemical	• Marketed technology, identified companies • Assisted with Technology Briefing • **Agreement signed, project underway**
Ice Detection System	JSC/ Raton Technology Research, Inc.	• Assisted in development of agreement • **Agreement signed, project underway**
Gamma Ray Collimator	SSC/ Instrument Marketing Services, Inc.	• Located potential licensee and advised them regarding license application • **License agreement signed**
Supersonic Gas-liquid Cleaning System	KSC/TBD	• Developed and distributed COA • Identified companies • Assisted with Technology Briefing • **Two companies interested in license**
Super-resolved Image Processing System	ARC/TBD	• Developed multimedia COA • **Two companies working with innovator to evaluate technology**

Highlights of the RTI Applications Team's activities during the reporting period are presented in Section 2.0. The RTI Team's activities in the development and implementation of a methodology for the assessment of the commercial potential of NASA technologies are presented in Section 3.0. Section 4.0 describes RTI's Commercial Opportunity Development activities during the reporting period. Section 5.0 presents the process and results of an Industry Analysis Initiative. Section 6.0 describes RTI's Coordination of On-Going Projects. Descriptions of active Add-on Tasks are presented in Section 7.0. The RTI Team's Travel during the reporting period is presented in Section 8.0. The RTI Team staff and consultants and their project responsibilities are listed in Appendix A. Appendix B includes examples of Technology Opportunity Sheets developed by RTI.

RTI has enjoyed the privilege of working with NASA to accomplish the important mission of commercializing NASA's technologies to the benefit of the national economy. The authors gratefully acknowledge the contributions of many individuals to the success of the RTI Technology Applications Team program. The time and effort contributed by managers, engineers, and scientists throughout NASA were essential to program success. Industry managers, technical staff, medical researchers, and clinicians have been cooperative and open in their participation. Most important to the program has been a productive working relationship with the NASA Field Center Technology Commercialization Offices. RTI looks forward to continuing opportunities to advance the goals of NASA in developing effective partnerships with U.S. industry.

2.0 HIGHLIGHTS

Projects

Visionics Corp. announced the commercial introduction of the **Low Vision Enhancement System** developed under a cooperative project between NASA Stennis Space Center and Johns Hopkins University (JHU). This project was initiated as a result of RTI assistance in defining the need and technical requirements, matching with NASA technology, and developing an agreement between NASA and JHU.

RTI assisted in the commercialization of the **Langley-developed Simpson Probe**. **Krautkramer Branson in Lewistown, Pennsylvania was selected as the Commercialization Partner** to license the technology. A license agreement was executed and a commercial prototype developed. The commercial product will be introduced in the first quarter of 1995.

RTI identified and contacted Instrument Marketing Services (IMS) regarding licensing the Stennis Space Center **Gamma Ray Collimator**. The Applications Team reviewed IMS's license application and prepared an executive summary for the document. In April, 1994, IMS was awarded an exclusive license to the technology and is actively marketing it for nondestructive evaluation.

RTI completed a **commercialization plan for the Langley-developed colorless, low dielectric polyimide materials**. As part of the commercial assessment, RTI developed a Technology Opportunity Announcement to facilitate conversations with industry about the NASA technology. RTI also revised the commercialization plan to use it as a market study for communicating the commercial opportunities. To date, the LaRC-RTI efforts have resulted in 2 Space Act Agreements and 3 license inquiries.

A Space Act Agreement was signed between Stennis Space Center and IVAC Corporation to employ the NASA-developed **predictive response algorithm to electronic thermometers** for hospital/clinic use. RTI introduced this technology to IVAC on behalf of Stennis Space Center. A commercial product is under development. IVAC has requested that NASA not publicize this cooperative effort until the product has reached the commercial market.

Healthdyne Technologies, Inc. (located via an RTI marketing effort) and the Florida Solar Energy Center signed a research and license agreement ($300K Healthdyne investment) to develop a **medical oxygen concentrator** based upon prior NASA research into electrolytic methods of oxygen separation from air.

A licensing partner was found for a **Spiral Fluid Separator** (USP 5,248,421), invented by Glen A. Robertson of Marshall Space Flight Center. The licensing partner, Charles E. Humphrey, is

establishing a company, GeoSpace Technologies, expressly to develop a prototype of the device and then market a final product.

RTI helped initiate four technology commercialization projects as a result of the efforts under the **NASA-National Cancer Institute (NCI) initiative in Digital Mammography**:

- Jet Propulsion Lab and Nanoptics, Inc. will develop a charge coupled device (CCD) imager with NASA and NCI support.
- Nova R&D, Inc. and the University of Toronto will build and test a silicon pixel detector with NASA and NCI support.
- Ames Research Center and the University of South Florida will test computer algorithms for feature detection with support from NASA Code UL.
- With NASA Code CD support, Jet Propulsion Lab will build readout electronics for a General Electric and EG&G developed amorphous silicon detector.

RTI made presentations on the **NASA/NCI digital mammography program** to the Technology Transfer Society Annual Meeting and to an HHS/NCI planning session for an upcoming Capitol Hill Conference on Novel Breast Imaging Technologies. In addition, RTI prepared the text and slides for a presentation by Joan Vernikos, NASA Code UL, to the Capitol Hill Briefing on New Frontiers in Breast Cancer Imaging (Oct. 11, 1994).

With funding support from the **National Center for Manufacturing Sciences (NCMS)**, NASA Langley Research Center is using the **Optically Stimulated Electron Emission (OSEE)** technique to inspect the cleanliness of printed circuit boards. The November 1994 issue of *NCMS Focus* contained a two page article on this project. Dr. Welch and Dr. Yost are awaiting final notification that their patent application has been awarded. RTI initially identified this opportunity, coordinated early discussions and pilot tests with industry, and helped negotiate an agreement with NCMS.

NASA Code C received thanks from Roger Lewis, Director, Office of Technology Utilization, U.S. Dept. of Energy (DOE) as a result of an RTI-generated opportunity with the **National Food Processors Association (NFPA)**. The opportunity resulted from the distribution of a problem statement, which dealt with food package integrity, to NASA and other agencies' labs (under our agreement with the FLC). The technologies of greatest interest to the NFPA were proposed by two DOE facilities, and to facilitate transition, RTI arranged a meeting with NFPA at DOE Headquarters.

RTI assisted Kennedy Space Center with a marketing program for their **supersonic gas-liquid cleaning system**. Working with the Technological Research and Development Authority (TRDA) of Florida, RTI completed a Technology Opportunity Announcement (TOA), invited companies from the precision cleaning industry, and assisted KSC with a technology briefing. A number of commercialization plans were submitted, with a decision yet to be made on which company(s) to work with to commercialize this technology.

Another promising opportunity, the **Particle Fallout Monitor** was identified at Kennedy Space Center. A marketing program was devised and implemented. It again involved collaboration with the TRDA and a technical briefing held near KSC for presentation of the technology to industry. Collaboration on the current version of the monitor is not as likely as it may be for the next generation.

RTI assisted Ames Research Center with marketing of three technologies that had been supported by the NASA **Operations Intercenter Work Group**: Temporal Directed Acyclic Graph (TDAG), Scientists' Intelligent Graphical Modelling Assistant (SIGMA), and Super-Resolved Image Processing System (S-RIPS).

RTI completed the **first multi-media presentation** for a new technology for Ames Research Center. The presentation, which described the **Super-Resolved Image Processing System**, was developed by an RTI team and can be transmitted — with "player" — on one diskette or by direct transmittal over the Internet. Use of this innovative marketing tool helped RTI to locate two companies with interest in the technology.

A **Commercialization Plan for LaRC-IA foam applications** was developed, identifying a commercial market for the foam and strategies for competition. Additionally, potential foam technology development partners were identified: Accurate Plastics, Bradford Industries, Elliott Company of Indianapolis, and Penn Fibre. While it is too early in the development of the product to establish a licensing partner, future distributors were also identified.

The Applications Team performed a market study on **mobile robot platforms** for Langley Research Center. Langley and Virginia Power are performing a technology transfer project to equip a mobile robot platform with modular hardware and software. The Applications Team surveyed the market, identified three companies that could supply the mobile robot platforms, and initiated negotiations with one utility which might donate a mobile robot to the project.

Research Triangle Institute assisted with a technology briefing (Commercial Opportunities Program) at Langley Research Center on their **low temperature oxidation catalysts**. Thirteen

companies came to hear the inventors discuss the prospects for commercializing their work. Interest is high and should result in several licenses and development projects.

The contract for development of **ice detection sensors/transmitters** between Johnson Space Center and Raton Technology Research (RTR) is in place. Significant progress has been made in the electronics package for the device. The most significant challenge at present is the position taken by the Federal Aviation Administration — the FAA favors scanning systems (such as infrared) over spot sensors. RTR continues to marshall support among the airlines and the aircraft manufacturers to try to affect this position.

RTI prepared a **market opportunity analysis for the Dried Blood Chemistry System** invented at JSC. RTI also forwarded to JSC a list of analytes that SciCor, Inc. is interested in testing with the JSC-developed device. This offers an opportunity for JSC to obtain corroborative test results for a set of analytes of specific industry interest.

RTI completed and distributed a final report for NASA Ames on the clinical trends and market potential for **negative pressure ventilation**. Report confirmed an unmet need, but concluded that this application represented limited market potential and probably did not warrant NASA taking a lead role. RTI undertook this effort at the request of NASA HQ Life Sciences.

RTI served as ad-hoc chair of the Medical Advisory Board (MAB) for the NASA **Robot Assisted Microsurgery** (RAMS) project at JPL. The MAB provided feedback and recommendations to JPL concerning the project plan and prospects for commercialization.

RTI prepared a Technology Opportunity Announcement for the KSC **Optical Broadcasting Wind Indicator**. The Applications Team worked with the Mid-Continent RTTC to develop a preliminary market analysis for a potential licensee. The Applications Team also referred a second company to the Mid-Atlantic RTTC.

RTI prepared a market assessment for the **Optical Measurement System** developed by NASA Langley. RTI also coordinated a conference call between Pixsys, Inc. and NASA Langley Research Center, and Pixsys has since received additional technical information and has made a visit to LaRC. Commercialization efforts are pending resolution of intellectual property rights with a NASA contractor.

RTI supported the Langley Technology Transfer Office in preparing for and presenting the **Ultrasonic Displacement Amplitude Measurement System** at the Langley Technology Opportunity Showcase (TOPS) and at a Technical Briefing During TOPS. RTI identified and

qualified participating companies, generated interest with an RTI-developed Technology Opportunity Announcement, and assisted with the briefing.

Following an RTI-organized meeting, NASA-Lewis received a letter from the National Eye Institute (NEI) expressing interest in testing the **Fiber Optic Cataract Probe** in a broader population once initial tests are complete. NASA HQ Code UG has committed to funding the prototype development.

RTI prepared a **market opportunity analysis for the Braille mouse and refreshable Braille display** inventions from NASA Langley. The report, which highlighted the commercial opportunity for the Braille display, was sent to Marisol Romero, NASA LaRC Technology Applications Group.

RTI completed a draft market opportunity assessment for the NASA Langley-developed **Fetal Heart Monitor**. Copies were sent to Frank Farmer at NASA and to a potential licensee, John Veal at Veatronics, Inc.

RTI initiated a new program under which University of North Carolina MBA students worked with RTI as part of their Practicum. At no cost to the project, these students assisted RTI in conducting market opportunity analyses and preparing commercialization plans for two NASA technologies. Five students have signed up for the 1994-95 Practicum.

Marketing/Outreach

RTI presented a paper entitled "Industry Association/Government Partnerships: A Model for Meeting Industry-Wide Technology Needs" at a February 2-3 **Dual Use Conference at Johnson Space Center**.

RTI participated in a panel chaired by NASA at the annual **Spaceweek Conference** at Vandenberg Air Force Base. RTI made a presentation on the development of partnerships between industry associations and NASA for dual-use projects.

RTI helped plan and participated in a workshop on **Technology Transfer in Image Guided Therapy** in San Francisco, Aug. 5, 1994. Sponsored by NASA, the National Cancer Institute and the Society for Cardiovascular and Interventional Radiology, the meeting outlined the state-of-the-art and technology trends in image guided therapy. RTI will assist NASA and NCI in identifying technology transfer opportunities to address needs in this field.

RTI had an article published in the June 2, 1994 *HazTECH News* newsletter which promoted the commercialization of the Lewis Research Center's **ion exchange material**. Front page coverage gave a good description of the technology as well as contact information for obtaining additional information. Several inquires were received as a result of this article.

The third of three articles on Technology Transfer was submitted to the **Hazardous Materials Control Resources Institute** (HMCRI) for their November 1993 issue of *Focus*. This series of articles was requested by the Director of HMCRI to inform their membership (over 5,000) about the opportunities and process for accessing NASA and other Federal lab technologies.

RTI attended the **Law Enforcement Workshop on Technology Transfer** in Washington, D.C. to investigate potential sources of problem statements.

RTI attended the Workshop on **Technology Transfer Opportunities for Business and Industry** in Huntsville, AL on March 23, 1994. The workshop was sponsored by Marshall Space Flight Center, U.S. Army Missile Command, and the U.S. Army Space and Strategic Defense Command.

RTI authored a paper, "Industry Association/Government Partnerships: A Model for Meeting Industry-wide Technology Needs" at the **Technology Transfer Society** in Huntsville, AL in June.

The RTI Technology Applications Team presented the problem statement development process at an **American Society of Mechanical Engineers** (ASME) organizational meeting. This group is beginning to form a consortium to develop continuous emissions monitoring technologies for industrial and hazardous waste combustion processes. RTI later attended the ASME Subcommittee meeting on Continuous Emissions Monitors for incinerator stacks. RTI will seek to develop problem statements addressing the needs of this group.

RTI and the Southeast RTTC co-exhibited at the **Society for American Gastrointestinal Endoscopic Surgeons** (SAGES) Annual Meeting. SAGES also published an article on technology transfer by RTI in their newsletter. RTI has put together a plan for working with the SAGES Technology Committee to prioritze technology needs in this industry.

Photographs, a video, and supporting information on NASA success stories provided by RTI to Judith Ambrus in the Office of Advanced Concepts and Technology, Code CF were used in conjunction with a television program on the benefits of space research presented by the **Public Broadcasting System (PBS)** in February, 1994.

RTI gave a presentation on **Federal Lab-Industry Partnerships for Technology Development** at the 2nd Carolina Biomedical Engineering Conference.

RTI gave a presentation to the **47th National Conference on the Advancement of Research.** The presentation covered the Technology Applications Team's activities in developing technology transfer projects to address critical industry needs.

RTI attended the **Comprehensive Technology Transfer Training Program** in Los Angeles, CA on January 26 and 27, 1994. This program was sponsored by the Association of Federal Technology Transfer Executives and the International Society for Optical Engineering.

RTI attended a meeting of the **NASA Sensors Working Group** and discussed technology commercialization services available from NASA Code XC and the RTI Technology Applications Team.

Assistance to HQ and Centers

RTI provided case studies of our market-pull approach with industry associations and consortia to Mike Weingarten, NASA HQ, in response to his request for input for the NASA Commercial Technology Management Team.

RTI provided information on Spinoff benefits to Tyrone Taylor and Mike Battaglia at NASA HQ for use in a response to the **Congressional Joint Economic Committee**.

RTI worked with the LaRC Technology Applications Group in the development of an **integrated process for assessing the patent, technical and commercial feasibility** of LaRC invention disclosures. RTI assisted in a presentation of this process to the LaRC Technology Council.

A **regional analysis of key industry sectors** and employment patterns in Alabama with detailed information by county and congressional district was conducted by RTI to assist MSFC in planning their outreach program. Focusing on the poultry industry, an industry important to the state, RTI also provided an assessment of the competitive position, regulatory requirements requiring technology, and key organizations/contacts.

A technology transfer flyer for the **wind shear detection** program was completed in time to be used by the Antenna and Microwave Research Branch at the Langley Research Center Technologies Opportunities Showcase.

RTI prepared for NASA HQ 100 viewgraphs and supporting information sheets on NASA Spinoffs and the NASA Technology Commercialization Process.

RTI provided LaRC a package of information on the **U.S. shipbuilding industry**, including information on the competitive position, recent initiatives to assist the industry, and areas of new development in which NASA technology may provide benefit.

RTI assisted the Johnson Space Center Technology Utilization Office in drafting a Memorandum of Understanding between NASA and Texaco to test the JSC **two-phase flow sensor**.

RTI completed the development of initial version of the **Learning Game software for teaching technology transfer** to Center staff.

RTI prepared a preliminary commercial opportunity assessment for the **JPL Adaptive Recognition Tool** (JARTool) developed by the JPL Artificial Intelligence Group. The assessment, which included a suggested approach to demonstrate the value of this technology, was sent to the innovator and to Bill Spuck (JPL), Jonathan Root and Mel Montemerlo (NASA HQ).

RTI assisted NASA HQ in setting up and staffing the **Spinoff Technology Application Retrieval System** (STARS) for a Rayburn Building congressional briefing. Congressional response was very positive. RTI followed-up by providing LaRC and KSC with information packages on spinoffs in their states for forwarding to Senators who had expressed interest.

RTI presented the results of a preliminary review of two related patent disclosures on **piezoelectric technologies** to researchers and members of the Langley Technology Transfer Office. The purpose of the assessment was to strategize on patent protection and commercialization. RTI's suggestions and reasoning were well received.

RTI completed an assessment (for Frank Farmer) of eight **rehabilitation project ideas** submitted to Langley Research Center by the Eastern Virginia Medical School.

Research Triangle Institute began work on a task for **Lewis Research Center** that will identify prospective company partners in each of three industries: surface transportation, environmental, and bioengineering. For each company, RTI will provide contact information, financial figures, and technical needs.

RTI provided assistance to NASA Ames in developing a project to use **liquid cooling garment** technology to address the body thermocontrol need of persons with spinal cord injury. Building

on a 1988 RTI study, RTI reassessed the need for this technology and identified potential industry partners.

RTI assisted with finding a solution for a cadmium plating problem (technical request) that was submitted to Marshall Space Flight Center.

The Technology Applications Team performed market assessments on a number of Kennedy Space Center new technologies. Among them were: Supersonic Gas-Liquid Cleaning System, Water-Driven Turbine/Brush Pipe Cleaning System, Structured Light Microscope for Measuring Surface Flaws, and Infrared Detectors for Hydrogen Leaks and Fires.

RTI provided an assessment of the instrumentation industry for KSC. The information provided by RTI included an industry definition, industry summary, and detailed information on relevant tradeshows and conferences. KSC will use the information during their participation in a NASA HQ review of the Technology 2000x series as a vehicle for reaching industry.

RTI completed development of the basic TechTracS system for technology tracking and completed installation at all of the Field Center Patent and Commercialization Offices with the necessary software. TechTracS software code was delivered to John Yin at NASA Ames.

3.0 TECHNOLOGY ASSESSMENT

Effective identification of commercialization opportunities requires a knowledge of the technical assets of the NASA Field Centers. To supplement RTI's on-going technology identification efforts, RTI developed and implemented a cost-effective approach to assess the commercial potential of new NASA Field Center technologies. Technologies are identified from the array of developments at a given Center; and initial assessments are performed to identify the most promising and commercially viable prospects. These assessments are used to focus NASA Field Center and RTI marketing resources on those technologies with sufficient market attractiveness.

The technology assessment process was developed primarily to help Langley Research Center deal with a large backlog of disclosures and patent cases. The method is shown graphically in Figure 1. After a NASA technology has been identified as promising, RTI performs an initial market evaluation to rapidly assess its potential commercial applications. First, RTI gathers published information along with information from the inventor(s) and the NASA technology transfer staff. Then RTI gathers market intelligence, including information on competing technologies and the value of the differential advantages claimed for the new technology. A key element of our approach is the use of experts to obtain technical and market information. Experts are identified among potential customers/users of the new technology and the potential companies who would adopt the technology and carry it to market. The evaluation is compiled in a brief report for NASA that includes an informed assessment of the likelihood that a new technology has sufficient market potential to attract serious industry interest.

Because RTI has a well-defined process, a set of available tools, and skilled evaluators, these assessments can now be done in less than two workdays of effort. Regardless of whether the technology is a strong candidate for commercialization, the RTI evaluator includes feedback in the evaluation report that is valuable to the innovator for future reference. The inventor may choose a slightly different approach in the next phase or next project that would better fit a market need as described in the evaluation.

1994 Assessment Activity

The Technology Applications Team performed market assessments on a number of Kennedy Space Center new technologies. Among them were: Supersonic Gas-Liquid Cleaning System, Water-Driven Turbine/Brush Pipe Cleaning System, Structured Light Microscope for Measuring Surface Flaws, and Infrared Detectors for Hydrogen Leaks and Fires.

RTI performed a technology review on two piezoelectric technologies for LaRC. A cursory commercialization plan was presented to the innovators and the appropriate LaRC Technology Applications Group members on February 17, 1994. The plan was based on review of related/competing patent, conversations with researchers, database searching, and industry assessment. RTI's suggestions were well received by LaRC.

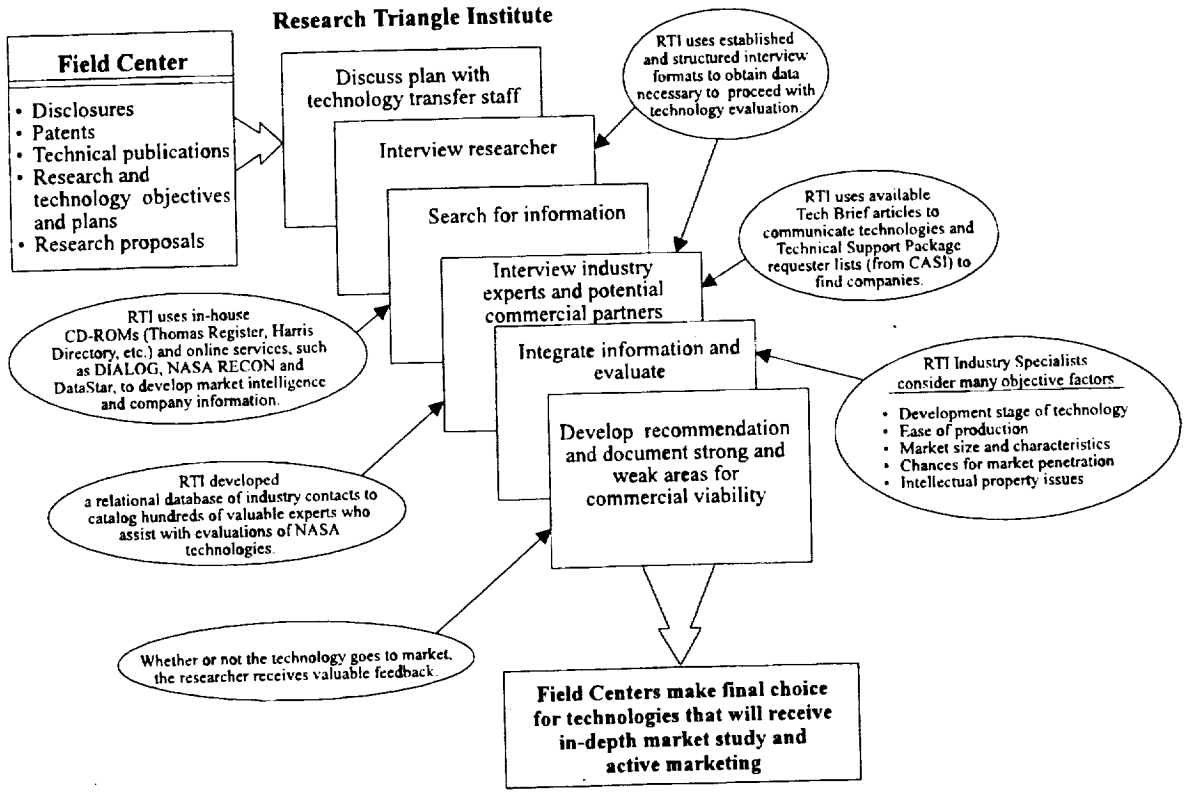


Figure 1: RTI technology assessment process.

Research Triangle Institute evaluated over 140 patent disclosures for Langley Research Center. The table below is a listing of the different cases that were assessed in the reporting period, a few of which are still under review at year's end.

RTI No.	NASA Case No.	Title
1	LAR 14849-1	Wavelength Division Multiplexing Digital Controller
2	LAR 14743-1	Ultra-High Efficiency, Ultra-Narrow Passband, Tunable Optical Filter
3	LAR 14981-1	Ceramic Optical Bench
4	LAR 15178-1-SB	Optical Measurement System
5	LAR 14533-1	Prepreg Slitter
6	LAR 15068-1	Electrically Conductive Polyimide Film Containing Gold (III) Ions
7	LAR 15052-1-CU	Electrically Conductive Polyimides Containing Silver Trifluoroacetylacetonate
8	LAR 14879-1-CU	Apparatus and Method for Determining the Mass Density of a Textile Yarn
9	LAR 14255-1	Analog-to-Frequency Converter Circuit for Pressure System Calibration Standard
10	LAR 14779-1	Thermocouple Inhomogeneity Test Fixture
11	LAR 14683-1	Predictive Failure Detector
12	LAR 14900-1	Acoustic Flameout Detector
13	LAR 14936-1-CU	Process for Preparing Electrically Conducting Polyimide Films
14	LAR 15212-1-CU	Test Fixture for Determination of Energy Absorbing Capabilities of Composite Materials
15	LAR 14240-1	Vacuum Holding Fixture for Fabricating Piezoelectric Polymer Acoustic Sensors
16	LAR 14935-1	Passive Venting Technique for Shallow Cavities on Subsonic and Transonic Aircraft
17	LAR 14784-1	Method for Desulphurization of Gas Turbine Blades
18	LAR 14995-1	Optical Measurement System
19	LAR 15065-1	Piezo-electric Pump
20	LAR 15121-1-CU	Method and Device for Using Thermoelasticity to Characterize Coatings
21	LAR 15129-1-CU	A Neural Network Based Algorithm for Computing Fetal Heart Rate in Support of a Passive Fetal Monitoring Sensor
22	LAR 15138-1	Piezo Loudspeaker and Transducer
23	LAR 15147-1	Method for Measuring Wing Twist in Wind Tunnels
24	LAR 15210-1	Blind Keyhole Insert
25	LAR 14899-1	Mechanical End Joint System for Connecting Structural Column Elements
26	LAR 15238-1	Part-span, Low-sweep, Supersonic Natural Laminar Flow Wing

27	LAR 14765-1	Programmable Analog to Digital Converter
28	LAR 15136-1	Variable Geometry Truss
29	LAR 14892-1	Composite Prepreg Material with Discontinuous Through-the-Thickness Rods to Improve Interlaminar and Intralaminar Strength of Composite Laminates
30	LAR 14856-1	Automated Current Driven Constant Temperature Anemometer
31	LAR 14103-1	An Acoustic Pump
32	LAR 15072-1	Adjustable Reed for Weaving Net Shaped Tailored Fabrics
33	LAR 14647-1-SB	Optical Fiber Distributed Temperature Sensor
34	LAR 14855-1	Video Strobe Synchronizer
35	LAR 15071-1	Active Control of Nonlinear-Nonstationary Response and Radiation
36	LAR 15137-1-CU	Model Protection and Shutdown System
37	LAR 15244-1	Trailing Edge Passive Porosity for Control, Stall Alleviation and Improved Performance
38	LAR 15246-1	Base Porosity for Drag Reduction
39	LAR 15265-1	Low Cost Butt Joint Shear Test
40	LAR 15267-1	Remote Light Emitting Diode Target System
41	LAR 14221-2	Stall Departure Resistance Enhancer
42	LAR 14338-2	A Tough High Performance Composite Matrix
43	LAR 14581-1-SB	Method and Apparatus for Evaluating Multi-Layer Objects Imperfections
44	LAR 14725-1	Synchronous Sampling Phase and Amplitude Detection Method and Apparatus
45	LAR 14785-1	Fault Tolerant Fiber Optic Backplane
46	LAR 14815-1-CU	Aerodynamic Design Optimization Using Sensitivity Analysis and CFD
47	LAR 14816-1-SB	High Speed Thin Plate Fatigue Crack Monitor
48	LAR 14863-1-CU	Non Rectangular Tow Preg Architectures
49	LAR 14926-1-CU	Powder Curtain Prepreg Process
50	LAR 15107-1	Multiple Layer Dielectrics, Hot Film Sensors, and Method of Producing
51	LAR 15229-1-CU	Toughness Modifiers for Epoxy Resins
52	LAR 13404-1	High Performance Car Anti-Lift System
53	LAR 13779-1	Variable Tile Helicopter Rotor Mast
54	LAR 13804-1	Stability Control, Reverse Flow Wing
55	LAR 13801-1	Polyarylene Ethers with Improved Properties
56	LAR 13818-1	Preloaded Space Structural Coupling Joint with a Two-Piece Locking Ring
57	LAR 15058-1	Vapor Generator Wand
58	LAR 14848-1	Hydraulic Load Frame for Combined Axial Tension and Bending Loads
59	LAR 15231-1-SB	Rotating Probe Method for Fatigue Crack Detection at Airframe Rivets Using Self-Nulling Probe

60	LAR 15112-1-CU	Micro-Sensor Thin Film Anemometer
61	LAR 14054-1	Shock Free Supersonic Elliptic Nozzles and Method of Forming Same
62	LAR 13580-1	Mechanical Strain Isolator Mount
63	LAR 14149-1-SB	Torsional Suspension System for Testing Space Structures
64	LAR 14840-1	Variable and Fixed Frequency Pulsed Phase-Locked Loop
65	LAR 15201-1-C	Lead-Insensitive Optical Phase Locked Loop Fiber Optic Sensor
66	LAR 15281-1	Active Pyroelectric Infrared Detector
67	LAR 15292-1	Passive Magnetic Bearing with Radial Centering and Axial Preload
68	LAR 15172-1-CU	Circular Electrode Geometry Metal-Semiconductor-Metal Photodetectors
69	LAR 14997-1	Optical Flameout Detector
70	LAR 14160-1	Remote Tire Pressure Sensing Technique
71	LAR 14640-1-CU	An Interferometer Having Fused Optical Fibers, and Apparatus and Method Using the Interferometer
72	LAR 14433-1	Ultrasonic Dynamic Vector Stress Measurement Method and Sensor
73	LAR 14513-1-SB	Deployable Reflector Structure
74	LAR 13370-1	Low Cycle Fatigue Test Procedure
75	LAR 13494-1	Dual Channel, Sky/Ground Shader
76	LAR 14496-1	Method of Forming Multi-Element Thin Hot Film Sensors on Polyimide (Kapton) Film
77	LAR 14910-1	Development of a Contact Lens Quality Monitoring System
78	LAR 14558-1	Litter Spinning Retarder
79	LAR 15061-1	Ice Thickness Measurements in the Presence of Liquids
80	LAR 15155-1-NP	Hardware to Improve Communication in Distributed Memory Parallel Computers
81	LAR 15300-1	Zero-Freeplay, Linear, Revolute Joint for Deployable Structures
82	LAR 13561-1	Improved Gas Jet Nose Tip
83	LAR 13567-1	Improved Process for Making CSP-LOC-NAME Lasers
84	LAR 13661-1	Method of Fabricating Circular Composite Structures
85	LAR 13834-1	Method for Suppressing Wind Tunnel Oscillations During Testing at High Angles of Attack
86	LAR 13909-1	Pilot Anti-Disorientation Device
87	LAR 13912-1	Method of Application of Polymer Powder Material on Carbon Fiber Tows
88	LAR 13922-1	Technique on Measuring Electrical Conductivity of Materials at Microwave Frequency
89	LAR 13928-1	Vertical Tail Strake
90	LAR 13971-1	2-Dimensional Macrograting Concentrator
91	LAR 14006-1	Chemical Sensors for Atomic Oxygen and Other Low Molecular Weight Species

92	LAR 14007-1	Fluorescence Chemical Sensor for Atomic Oxygen/Molecular Oxygen Species
93	LAR 14020-1-CU	Belt Skin Friction Balance
94	LAR 14035-1	Dual Fuel Expander Cycle Rocket Engine
95	LAR 14061-1-CU	Austere Ultrahigh Vacuum Sample Preparation Chamber
96	LAR 14126-1-CU	Linear Ultrasonic Motor
97	LAR 14684-1	Zero-Spring Rate Mechanism Air Suspension Cart
98	LAR 15314-1	Twin Rolling Element Bearing
99	LAR 14448-1-SB	Lightweight Protective Coating
100	LAR 13950-1	IBM Printer Port Interface
101	LAR 14738-1	Single Acting Translational/Rotational Brake
102	LAR 14788-1	Planar Spring Tine Wind Tunnel Mount System
103	LAR 14845-1-SB	Adjustable Tensile Test Transducer for Measuring Elongation of Small Composite Specimens
104	LAR 15256-1	Binary Trainer for All Ages in Any Grade/Simple Security System
105	LAR 15053-1	A Schlieren System for Aircraft in Flight
106	LAR 15050-1-SB	Collecting Light from an Optical Fiber with a Numerical Aperture Greater than One
107	LAR 15159-1-SB	Strain Insensitive Optical Phase Lock Loop
108	LAR 15170-1-SB	Methods to Simultaneously Determine Temperature and Strain
109	LAR 15184-1-SB	Making Light Emitting Diodes, LEDs, More Efficient
110	LAR 15335-1-SB	Methods to Determine Temperature & Chemical Distribution at Specific Locations Along an Optical Fiber
111	LAR 15040-1-CU	Method for Tissue Characterization and Diagnosis of Pressure Ulcers (Bedsores) in Humans
112	LAR 13969-1	Novel Laser Diode Pumped Solid State Laser Configurations
113	LAR 14012-1	Programmable Waveform Generator
114	LAR 14013-1	Earth-to-Orbit Transport with Alternate Staging Capability
115	LAR 14069-1	Personal Computer Disc Drive Lock
116	LAR 14083-1	A New Method of Transporting and Pouring Stainless Steel
117	LAR 14134-1	Combined Rocket and Airbreather Powered Aerospace Plane with Takeoff & Landing Augmentation
118	LAR 14951-1	A Frequency Differencing Circuit
119	LAR 14984-1	3-Axis Compliant Coupling Device for Robotic End-Effectors Requiring Precise Prepositioning
120	LAR 15111-1	LVABI Interface
121	LAR 15439	Potential Liquid Crystalline Polyimides
122	LAR 14758-1	Flat Plate Rotator
123	LAR 15259-1-CU	Composite Prepreg Consolidation Device
124	LAR 15288-1-CU	Refractory-Composite/Heat-Pipe Cooled Leading Edge
125	LAR 15114-1	A Dry Process for Making Uni-Tape Prepreg From Powder Coated Towpreg
126	LAR 14882-1	Autozero Unit

127	LAR 15211-1	Beat Frequency Ultrasonic Microsphere Contrast Agent Detection System
128	LAR 14186-1	Polyamideimides Containing Specific Connecting Groups
129	LAR 14566-1-SB	An Improved Means to Produce Wrought Articles From Powder or Particles
130	LAR 14734-1-SB	Temperature Regulator for Actively Cooled Structures
131	LAR 14938-1-SB	High-Temperature Hydraulic Grips
132	LAR 15062-1	Multi-Channel Electronically Scanned Cryogenic Pressure Sensor
133	LAR 13835-1	High Lift V/STOL Aircraft Fuselage Shapes
134	LAR 13944-1	Schlieren System for Visualizing the Flow Within A Pipe of Circular Cross-Section
135	LAR 14154-1	Graphite Fiber Reinforced Thermoplastic Pultrusion Process, Device & Dies
136	LAR 14368-1	Tribotuminescent Fiber Optic Sensors for Health Monitoring of Structure
137	LAR 14501-1	Solid State Laser System for Measurement of 0_3
138	LAR 14502-1	Cube Container Box
139	LAR 14509-1	Pollution-Free Automotive Air Conditioner
140	LAR 14545-1	Dimpled Waveplate Coupler for Unstable Resonators
141	LAR 14889-1	Eccentric Fuel Injector
142	LAR 14927-1	Precision Machining of Composite Honeycomb
143	LAR 15039-1	Catalyzed Imidization for Making Thermally Stable Polyimides at Room Temperature
144	LAR 15094-1	Concept For A Ringless Carbon-Carbon Piston in Internal Combustion Engines

4.0 COMMERCIAL OPPORTUNITY DEVELOPMENT

PROJECT TITLE: **Braille Mouse and Refreshable Braille Display**

SOURCE OF OPPORTUNITY: **NASA Langley Research Center**

RTI Team Personnel: Daniel Winfield

Background

Since being invented by Louis Braille in 1829, the Braille reading system has become widely used by the blind. Hardcopy Braille format have been standardized, and hardcopy Braille printers and notetakers are widely available. As we have entered the information age, the need for access to text in electronic format is important for blind people in work, home, and recreational settings. This project investigates the market potential of two electronic Braille inventions by an engineer at NASA Langley.

NASA Technology

Doug Garner, NASA Langley, has invented two electronic Braille devices. The "Braille Mouse", for which a patent has been issued, consists of a single Braille cell of six, electromagnetically actuated dots. The mouse can be moved to traverse a single line of text while the Braille cell displays a single character at a time. Movement to the next line is accomplished by a click of the mouse button. A prototype Braille Mouse has been built and tested at Langley. The second invention is a design for a refreshable Braille display using electrorheological fluids as the electromechanical actuation mechanism. The design, subject of a patent application, takes advantage of the properties of electrorheological fluids to achieve a full page (or at least multi-line electronic Braille display). No prototype work has been undertaken on this second invention.

Participants

Doug Garner, NASA Langley Research Center
Marisol Romero, NASA Langley Research Center

Status

At the request of Marisol Romero, LaRC Technology Applications Group, RTI performed a market assessment of these two devices. RTI first revisited previous studies of the need for electronic Braille output devices, including a study conducted by SAIC. RTI then contacted several leading professionals in the field including Larry Scadden of the National Science Foundation and Deborah Gilden of the Smith Kettlewell Eye Research Institute. Additionally, contact was made with several companies currently serving this market with single or double line

refreshable Braille displays. From these discussions, we concluded that there was minimal interest in the single cell Braille Mouse. While intuitively this has some merit, previous attempts at single cell displays, including a project by IBM, have met with no success due to the difficulties in reading with a single cell display.

On the other hand, significant interest exists both in the user community and in industry in full page or multi-line refreshable Braille displays. All past efforts have been unsuccessful in meeting the technical requirements in a cost effective manner. Current products in this market sell for $5,000 to $15,000. Most products are single line displays with a few manufacturers providing two line displays. The industry is very interested in any technology which will enable six or greater lines to be displayed quickly while maintaining costs below $15,000 (considered to be an upper price limit). Below this price, the market potential may reach 700-800 devices per year. Enthusiasm for this opportunity must be tempered by the fact that no engineering work has been undertaken to date. While the electrorheological fluid design should prove less costly than other alternatives, there is no way of knowing if it will meet both the technical and cost parameters for success. The likelihood of a successful transfer and commercialization is also hampered by the fact that there is very little funding for R&D into products of this type. Most interested companies expressed that they would prefer to see a workable prototype before they would invest heavily in product development.

PROBLEM TITLE: **Colorless, Low Dielectric Polyimide Materials**

SOURCE OF OPPORTUNITY: **NASA-Langley Research Center**

RTI Team Personnel: Molly O'Donovan Dix, Stephen A. Lehrman

Background

Conventional polyimide materials used in aerospace and commercial applications typically are limited by several inherent properties. To meet NASA's need for high temperature, flexible polymeric film and coating materials, the Langley Research Center developed a family of fluorinated polyimides that have high optical transparency and radiation stability for space applications. Although there are commercially available materials that are transparent, their long term thermal stability is limited. NASA has long used Kapton® with a silicon dioxide topcoat as a protective coating for spacecraft applications. Kapton's amber color is acceptable for microelectronic and electrical insulation, however, for solar arrays, reflectors, and thermal control systems, NASA required a transparent, colorless material with better thermal stability and greater resistance to radiation.

NASA seeks to identify a commercial partner to either license the existing LaRC technology or benefit from the expertise at Langley to develop a new related material. RTI is assisting LaRC in a commercial assessment of the technology. Based on the assessment RTI will also provide a strategy for commercialization of the technology.

NASA Technology

In the mid to late seventies, NASA began researching methods for reducing the possibility of inter- and intramolecular complex formation in polyimide materials. NASA believed these charge transfer complexes were responsible for the material's yellow color. Linear aromatic polyimide films and coatings were prepared by the polymerization of a highly purified aromatic diamine monomer and a highly purified dianhydride monomer in a solvent medium. This new process involved two conditions:

(1) purification of both of the reactants and the solvent, and
(2) elimination of chromaphoric centers and reduction of both inter- and intrachain electronic interaction.

The resulting polymer films were 80-100% transparent in the visible spectrum (400-600 nm), a 100% or greater improvement over commercially available polyimides.

As part of this research, NASA introduced fluorine containing groups to the polyimide backbone thus producing transparent polymers that were highly electrically insulative and resistant to

moisture. NASA's investigation of over 100 polymers has resulted in numerous linear polyimides that exhibit low dielectric constants in the range of 2.4 to 2.8 at 10 GHz. From a performance standpoint, these polyimides have the potential to be superior to the commercially available polyimides currently used as materials for wire coating, flexible printed circuit boards, and multichip module interlevel dielectrics.

Participants

Anne St. Clair, LaRC Materials Division
Dr. Terry St. Clair, LaRC Materials Division
Greg Manuel, LaRC Technology Applications Group
Dr. George Helfrich, LaRC Patent Office
Peter Agostino, ChemDev
Jack Keating, Imitec
L'Garde
Kent State University Liquid Crystal Institute

Status

The team worked closely with Anne St. Clair to understand the technologies that comprise the family of colorless and low dielectric polyimides. Because of the complexity of the technical subject and numerous chemical combinations, an early task identified by the team was to define the specific technologies to be assessed for commercial potential.

To facilitate a complete industry assessment, RTI arranged to have assistance from two graduate students at the Kenan-Flagler Business School. The students' experience with RTI/NASA will be applied to their graduation requirements as their practicum. The students focused on a top-down industry assessment looking at the five major forces impacting the market. These include:

i) industry entry and exit barriers
ii) rivalry within the industry
iii) power of suppliers
iv) power of buyers
v) threat of substitute products

RTI focused on bottom-up analysis by defining the technology (or product) and assessing potential market applications. This preliminary analysis was presented by the team to the Langley Technology Utilization Office, Anne St. Clair, Dr. Terry St. Clair and Dr. George Helfrich on February 17, 1994 at Langley.

On April 22, 1994 the team presented the final analysis of the commercialization study. Because the technology is a material that lends itself to many applications, the group presented findings and conclusions as to which applications/markets will most benefit from the properties of the LaRC materials. The commercialization effort will thus aim for higher impact areas.

As a result of the commercialization plan, RTI has worked with LaRC to execute two Space Act Agreements (ChemDev, L'Garde) and a working relationship with KSU Liquid Crystal Institute. Two license applications have been received (ChemDev, Imitech) and Johnson Controls has also expressed interest.

PROBLEM TITLE: **Commercialization Plan for LaRC-IA Foam Technology**

SOURCE OF OPPORTUNITY: **NASA-Langley Research Center**

RTI Team Personnel: **Molly O'Donovan Dix, Stephen A. Lehrman, Laura Schoppe, Charles Chiklis (Consultant)**

Background

The report analyzes the potential commercialization of the NASA LaRC Improved Adhesive (LaRC-IA™) polyimide foam. This information and a recommended strategy for market entry may be used by LaRC technology transfer management and researchers to make decisions concerning the continued development and commercialization of the LaRC-IA™ foam. The application and market analysis may also be used by potential commercialization partners in developing effective commercialization plans.

The Commercialization Plan presents the results of the RTI/NASA project to assess and plan for the commercialization of polyimide foam technologies developed by Dr. Terry St. Clair and the Materials Division at NASA's LaRC. The report begins with an industry overview that presents the participants and applications in the high temperature foam and insulation industry. The report further explores specific markets and develops a strategy for market entry into these commercial ventures.

RTI developed and used two Technology Opportunity Announcements (TOA) to facilitate dissemination of information on the LaRC-IA™ polyimide materials to commercial industries. The report also includes a list of companies the TOAs were sent to, the telephone questionnaire format, summaries of relevant telephone conversations, competitor material specifications, sample industry literature, and selected portions of annual reports.

NASA Technology

Because the LaRC-IA™ foam is in its initial stages of development and specific properties are unknown, the report concentrates on markets requiring materials with similar general characteristics. Primarily, the LaRC-IA™ foam was compared to *Rohacell*®, *Solimide*®, and *Insulimide*™, structural and insulation polyimide foams currently on the market.

Low density polyimide foams are ideally suited for marine and aeronautical applications. At a density of 0.5 pounds/cubic foot (PCF) and a thermal conductivity (K factor) of 0.042 W/m • K, polyimide foams can provide weight savings of up to 10 tons per 100,000 board feet when compared to traditional (e.g. fiberglass) insulation. The weight reduction is extremely important in marine and aircraft applications. Traditional insulating materials have lower K factors but on

a K factor per unit weight basis, polyimide foams can be up to 7 times more effective. In addition to weight savings, there are also health related incentives to using polyimide foams to reduce the possibility of human exposure to fibrous, inorganic particles (fiberglass, mineral wool, calcium silicates, ceramic fibers), thus older ships are being retrofitted with polyimide foam panels.

Highly aromatic polyimides are also inherently fire resistant and do not support combustion. They generate little, if any smoke and no toxic fumes. Slab polyimide foams exposed to a flame only produce a char. Whereas, almost all other organic foams and *Rohacell*® are flammable and can generate smoke and produce toxic gases when burned. Organic foams and *Rohacell*® thermal performance can be improved using flame retardant additives but they cannot compare with polyimides for safety from fire or for high temperature applications, especially since their maximum service temperatures are significantly lower (75 to 205°C).

The acoustical absorption coefficient of polyimide foams meet or exceed the sound absorption requirements of DOD-1-24688 at all frequencies. Thus making these foams ideal for insulation applications requiring sound absorption, such as Naval surface ships and submarines or aircraft.

On the other hand, polyimide foam panels are more expensive than traditional inorganic fibrous insulation. However, the rigidity of the polyimide panels make them much easier to handle, resulting in substantial reductions in labor installation costs, making the total cost of insulation competitive. Economic considerations coupled with substantial weight savings (ship weight above the water line) and freedom from dust and skin irritating inorganic fibers, make polyimide low density rigid foams an ideal material for marine and aeronautical applications.

The report recommends that the LaRC-IA™ foam be developed in two densities, 0.55 and 2.0 PCF, both of which would compete with *Solimide*® and *Insulimide*™ as a high performance insulation in the marine and aeronautical markets. Due to large cost discrepancies, it is not recommended that LaRC-IA™ be developed for competition against *Rohacell*® as a structural foam (foam densities greater than 5 PCF).

Participants

Research/Inventor	Dr. Terry St. Clair
Langley Technology Transfer	Greg Manuel
Langley Patent Office	Dr. George Helfrich
Research Triangle Institute	Dr. Charles Chiklis (consultant)
	Molly O'Donovan Dix
	Stephen A. Lehrman
	Laura A. Schoppe

Potential Foam Technology Developers	Accurate Plastics Bradford Industries Elliott Company of Indianapolis Penn Fibre
Potential Marine Distributors	Claremont Stephenson & Lawyer Waco

Status:

The Commercialization Plan was submitted in December, 1994. Partners for foam technology development will be pursued in 1995 at the direction of the LaRC Technology Transfer Team and the inventor, Dr. St.Clair.

PROJECT TITLE: **Dried Blood Collection and Storage**

SOURCE OF OPPORTUNITY: **Johnson Space Center**

RTI Team Personnel: Daniel Winfield

Background

Analytical chemistry of blood is important for the vast majority of clinical conditions. In conventional procedures, blood is drawn into sealed containers; stored until time for testing; and separated into smaller vials for testing of specific analytes. Storage times may vary from hours to days to weeks depending on the circumstances. For many important clinical chemistry tests, the blood must be refrigerated if storage times exceed an hour or so. A device which would provide for blood samples to be stored in a dried state would be useful in some circumstances if it allows rehydration and valid testing.

NASA Technology

Long Space Shuttle missions may last up to two weeks. Many physiological experiments into the effects of spaceflight require daily blood samples to be taken from animal and/or human subjects. This blood typically needs to be refrigerated, and refrigeration space is at a premium due to the weight and power requirements of refrigerators. To address this problem, NASA Johnson Space Center scientists have developed a system which allows for a blood sample to be placed onto a card and dried under controlled conditions. This dried sample then can be stored under ambient temperatures, the only requirements being low humidity and darkness. Upon return to Earth, all samples from the experiment can be rehydrated and tested under identical conditions.

Participants

Dr. Peggy Whitson, NASA JSC
Dr. Vaughan Clift, McDonnell Douglas

Status

RTI visited Johnson Space Center in August 1993 for meetings arranged by the Technology Utilization Office to explore new technology transfer opportunities. During these meetings RTI learned of the Dried Blood Collection and Storage System being developed by JSC. After additional testing over the next few months, JSC requested RTI perform a market opportunity analysis for this technology. The purpose of this analysis was to help target this technology

toward commercial applications having the greatest need for the specific advantages offered by the technology.

Following an initial assessment of the overall clinical chemistry market, RTI undertook a segmentation of the market. This segmentation included breakouts by both analytes of interest and point-of-use. Reference laboratories play an important role in this market as they service and have influence over many of the other segments of the market. Thus our report recommended targeting reference labs for market penetration. RTI's market opportunity analysis recommended targeting four market segments: reference labs, hospitals, clinical trials, and veterinary. In addition, the report identified several advanced developments that JSC might consider that would help determine the full advantages of the technique and make it more marketable to industry. One of the RTI contacts, SciCor, Inc. performs clinical chemistry testing for worldwide pharmaceutical clinical trials. They indicated significant interest in the device for certain specific analytes that now require refrigeration during shipment. SciCor offered to perform testing for these analytes and to share the results with NASA. This information and the SciCor contacts have been passed along to NASA JSC.

PROJECT TITLE: **Frost Prevention and Elimination on Air-Conditioning and Refrigeration Evaporator Coils**

SOURCE OF OPPORTUNITY: **Air-Conditioning and Refrigeration Institute**

RTI Team Personnel: Stephen A. Lehrman

Background

There are two primary areas where new frost prevention or elimination techniques are needed in air-conditioning and refrigeration systems. First, commercial refrigeration systems usually have their evaporation coils inside the space to be refrigerated. This is the case with most supermarket refrigeration products: walk-in-coolers, refrigerated cases, etc. The problem is that moisture in the conditioned air condenses on the coils and freezes onto the tubes, causing frost buildup, and inhibiting heat transfer.

The second area of need for frost prevention or elimination is on the outdoor coils of refrigerant-to-air heat pumps. Split systems and single-packaged rooftop refrigerant-to-air heat pumps are a common system for residential/commercial heating and cooling. In the heating mode, this equipment is operated in "reverse cycle", meaning that the outdoor coils act like evaporators and will condense outdoor ambient moisture on the coils/fins. The moisture eventually freezes onto the tubes, thereby impeding proper heat transfer.

Frost forms on refrigerant-to-air evaporator coils whenever the coil temperature is below freezing and the ambient air dew point is above the coil temperature. Frost increases the energy usage of air-conditioning and refrigeration systems in three ways:

(1) frost accumulation restricts air flow and reduces heat transfer efficiency,
(2) frost removal requires the addition of energy, and
(3) defrost methods typically do not terminate promptly after frost removal, resulting in the waste of additional energy.

Total energy use by heat pump systems can be reduced by about 5% if defrost is achieved on demand and promptly terminated. For commercial refrigeration equipment, the energy saving may approach 10%. Technology developed for frost control also would reduce environmental humidification needs. These technologies may also result in significantly more efficient residential northern climate heat pump systems.

NASA Technology

Goddard Space Flight Center recommended using a very thin layer of Teflon to coat the evaporator coils. The NASA researcher suggested that the Teflon would increase the contact angle for the water to such degree that it would be difficult for ice crystals to form and adhere to the surface.

Marshall Space Flight Center suggested an innovative concept for re-designing the evaporator coil into a primary section and a frost growth section. The primary coil section would be similar to conventional evaporator coils and would provide the heat exchange. The frost growth section, located upstream of the primary coil section, would promote frost accretion and, thereby, remove the driving force for frost growth on the primary coils. Marshall also cited Russian literature on the nucleation of water droplets.

Langley Research Center suggested applying a NASA patented ice detection and thickness sensor to monitor frost formation on the evaporator coils.

Participants

Mr. Glenn Hourahan, ARI

Status

The seven responses were reviewed by ARI and its technical committee. ARI did not feel that any of the responses provided a complete solution to the problem and, therefore, declined to initiate a project. One of the members of the technical committee, Heatcraft Inc, was sufficiently interested in the MSFC technology to request a conference call. RTI conducted the conference call. Following the conference call, the company decided not to redesign the air conditioning sections.

PROBLEM TITLE: **Galvannealing Reaction Monitor**

SOURCE OF OPPORTUNITY: **International Lead Zinc Research Organization, Inc. (ILZRO)**

RTI Team Personnel: Stephen A. Lehrman

Background

An on-line means of determining the extent of the iron-zinc alloying reaction in hot-dip galvanized steel, either during or immediately following the galvannealing reaction is desired. If located in the immediate area of the galvannealing furnace, a non-contact method is desired. Alternatively, a contact method can be used at the point where the coating contacts the next support roll immediately following galvannealing, a distance of typically 5 meters.

Production of rust resistant autobody sheet for many US automobiles is based upon hot-dip galvanizing, by which a thin layer of zinc is coated onto steel sheet, followed by a thermal alloying treatment termed galvannealing. Annealing of the zinc-coated steel sheet allows the interdiffusion of zinc and iron which forms an alloy coating. The iron content in the coating depends largely on the anneal temperature and time, with up to four iron-zinc intermetallic phases capable of forming. These range from the iron rich Gamma phase which forms a thin layer at the steel surface, to the Gamma-1 and Delta phases which appear generally as thicker layers and finally to the zinc rich Zeta phase which forms at the coating surface.

Immediately on top of the steel, a layer of Gamma, no thicker than 0.5 μm, is usually present. Above this layer, a mixture of Delta and Zeta phases is present. Some customers prefer Zeta-rich coatings and some prefer Delta-rich. Steel companies have developed methods to produce either.

The presence of each phase in the coating controls the performance of the material in different ways. The Gamma phase is generally a hard thin layer with high iron content making it easier to weld, but hard to form. Additionally, its corrosion resistance is little better than iron. Corrosion resistance and formability improve for the phases containing more zinc. The Delta phase is the most ductile and corrosion resistant of the four phases.

The makeup of the final coating significantly influences the forming, painting, welding, and corrosion behavior of the steel sheet during automobile manufacture and use. At present, the extent of the galvannealing reaction can only be determined by measuring the total iron content of the coating by metallographic analysis conducted long after coating manufacture. This reaction largely depends upon furnace temperature and time of heat treating, although different high-strength steels can have different reactivities, giving different end results for the same processing details.

An on-line galvannealing reaction monitoring system would provide greater quality control for the iron-zinc alloy coating and greatly reduce reject rates due to coating flaking or cracking or both that occur during autobody part stamping. This advancement would potentially allow the use of corrosion resistant steels in more critical forming applications.

A means for monitoring the extent of the galvannealing reaction on the galvanizing line is not currently possible. Input variables that can be monitored include the incoming temperature of the strip and coating prior to galvannealing, the coating composition, the steel reactivity, strip speed, and the temperature profile through the galvannealing furnace.
At present, the most widely used method of determining the extent of the galvannealing reaction is believed to be the total iron content. Total iron content can be determined by gamma or X-ray excitation of the coating to give a resultant signal. X-ray analysis can be used for coating weight determination on-line. Gamma ray analysis is only used in the lab. However, the answer given for total iron content in the coating is not unique because the signal can also be influenced by the total coating weight. Strip vibration is significant during processing and can also influence the output signal. For this reason, this technique is not widely used for on-line monitoring in steel mills, either domestically or internationally.

A laboratory tool borrowed from physics called Mössbauer spectroscopy is proving to be the most effective way of determining the makeup of galvanneal coatings. Mössbauer spectroscopy provides exact information on how each phase is present in the coating. Because it senses only the state of Fe^{57}, it takes anywhere from several hours to several days to produce a data point. ILZRO is trying to speed up data collection by developing a 3-way (X-ray, Gamma ray, secondary electron) detector. During 1992, ILZRO began sponsorship of a program to develop a complete database of Mössbauer spectroscopy parameters for the four iron-zinc phases found in galvanneal coatings. The database exists on paper and should be available on computer by mid-1994. This standard database could be used to develop on-line monitoring systems capable of identifying the phases formed during production of galvannealed coatings.

Radiation techniques such as light, electromagnetism and other nuclear effects could also be used to generate signals from the galvanneal coating at various states of completeness in its reaction. One of these techniques is to measure the thermal emissivity of the coating as it emerges from the galvanneal furnace or even slightly before this point if effects from furnace components can be removed from the signal. Thermal emissivity properties in galvanneal coatings change rapidly as galvannealing proceeds. The coating starts out highly reflective and ends up matte. The initial shiny surface ($\in \approx 0.1$) of free zinc changes to a dull appearance ($\in \approx 0.7$) as alloying becomes complete. However, it is matte for much of the galvannealing reaction, so that optical reflectivity then is fairly constant during the time of interest.

Monitoring techniques such as measuring the magnetic properties of the sheet with eddy current probes, using polarized light, or weak electron excitation may be possible. The latter is particularly attractive because electrons will not penetrate very far into the coating and thus only

the top surface layer would be excited, producing a signal which could be analyzed and correlated with the extent of the galvanneal reaction.

Another technique which has been recently developed for analysis of steel sheet passing at high speed is computer-aided image analysis. It may be possible to carry out image analysis on signals from many of the excitation sources noted above, including visible light. If this is possible, a significantly better degree of control could be exerted over the galvannealing reaction.

NASA Technology

The Langley Research Center proposed using magnetic eddy current and backscatter spectrometer technologies to inspect the coatings. RTI met with the researchers at Langley. The eddy current technology can identify crystal structures with differing magnetic properties. RTI arranged for Bethlehem Steel to send test coupons to Langley for magnetic eddy current inspection. The backscatter spectrometry work was performed in the 1970's. Much of the hardware has been dismantled and given to Old Dominion University, where the research is being continued. It was not felt that Langley had sufficient capability in this area to conduct a feasibility demonstration.

Status

Bethlehem Steel has sent test coupons to Dr. Min Namkung of Langley for testing using magnetic eddy current probes.

PROJECT TITLE: **Low Temperature Oxidation Catalysts**

SOURCE OF OPPORTUNITY: **Langley Research Center**

RTI Team Personnel: C. Gary Hughes

Background

NASA's Langley Research Center (LaRC) has acquired considerable experience and technical expertise in the development and application of low-temperature oxidation catalysts. This expertise arose from the solution of problems associated with the ambient temperature regeneration of carbon dioxide (CO_2) in long life space-based CO_2 lasers. The electrical discharge used to energize CO_2 lasers decomposes some CO_2 to carbon monoxide (CO) and oxygen (O_2). If the decomposed CO_2 is not replaced or regenerated, the performance of the laser eventually becomes seriously degraded and complete laser failure can ensue. In space-based applications, CO_2 must be regenerated rather than replaced since the replacement of decomposed CO_2 is impractical due to weight and volume constraints. Furthermore, in order to maintain laser efficiency, the catalytic recombination of CO and O_2 must occur at ambient laser temperatures, typically in the range of 50-60°C. Consequently, in order to maintain the efficiency and longevity of space-based CO_2 lasers, it became necessary for NASA researchers to develop catalysts which could oxidize CO to CO_2 with high efficiency near room temperatures.

NASA Langley had developed a collaborative project with Rochester Gas & Electric (RG&E) to evaluate the ability of the LaRC catalysts to treat indoor air. Results were good, leading to the need for finding companies to commercialize these catalysts. As stated below, the Langley catalysts have many applications in addition to treating indoor air.

NASA Technology

Traditional oxidation catalysts have generally fallen into two groups: noble metals such as platinum (Pt) or palladium (Pd) dispersed on a nonreducible-oxide support, such as alumina (Al_2O_3) or silica (SiO_2); and nonprecious, reducible metal-oxides and combinations thereof, such as Hopcalite, which consists primarily of a mixture of cupric oxide (CuO) and manganese dioxide (MnO_2).

Catalysts of the first group frequently have good activity at high temperatures (300°C and above) but generally have very low activity at room temperature. Some catalysts of the second group such as Hopcalite, which is a standard commercial catalyst for ambient temperature oxidation of CO in air, have useful activity at room temperature, but their activity is not high. Recent research has revealed that a combination of the two traditional groups of oxidation catalysts — i.e., one or more noble metals combined with one or more suitable reducible oxides — can exhibit

significantly higher catalytic activity, at low temperature, than either constituent alone. Probably the most extensively studied NMRO catalyst to date is platinized tin-oxide Pt/SnO_2. The principal impetus for research on Pt/SnO_2 has been in its demonstrated capability to catalyze recombination of small, stoichiometric concentrations of CO and O_2 at ambient temperatures to regenerate CO_2 in closed cycle CO_2 lasers. Recently, Pt/SnO_2 has also been shown to be an excellent catalyst for the room temperature oxidation of CO in air, with at least five times more activity than Hopcalite.

One result of the extensive research at Langley Research Center on Pt/SnO_2 has been the determination of the mechanism by which this material catalyzes the reaction of CO and O_2. The major features of the oxidation mechanisms proposed for Pt/SnO_2 catalyzed CO oxidation are also believed to be broadly applicable to other noble metal and reducible oxide (NMRO) catalysts and to other gaseous species, including hydrocarbons and other organic and inorganic gasses. Therefore, the following hypothesis is proposed: in general, any gaseous species which will chemisorb on some catalyst component, A, but not on another component, B, should be oxidizable on a suitably hydroxylized catalyst of the form, $ABO_x(OH)_y$, provided (1) the oxidation is thermodynamically favored and (2) O_2 chemisorbs on B.

Benefits

The higher effectiveness of the LaRC developed Pt/SnO_2 catalyst was determined by tests and comparative characterization with a commercially available catalyst. This LaRC catalyst has a high BET (Brunauer, Emmet, and Teller) surface area and a high activity at moderate temperatures. It is ten times as active as the commercially available Pt/SnO_2 catalyst under similar conditions. The new technique can achieve much higher ratios of Pt to SnO_2 than current methods. In addition, the LaRC researchers have determined that the best ratio of Pt to SnO_2 is in the 15-20% range. These loadings can be achieved with the demonstrated process. On the other hand, state of the art methods have been limited to 2 to 3% Pt to SnO_2. It can also be loaded on a substrate at up to 20 times the conventional surface density. The LaRC-developed process is inherently clean in that excess reagents or products decompose and evaporate, leaving no soluble residue. This new catalyst was formulated to have a very high surface area and to chemisorb controlled quantities of moisture — chemisorbed water is contained within and upon its structure making it highly active and very long-lived, so that only a small quantity of the catalyst is required. Furthermore, the reactions proceed at temperatures low enough so as not to decrease the surface area of the catalyst.

The unique characteristics of NMRO catalysts suggests that a large number of important oxidative reactions that presently occur only at high temperatures may be achievable at much lower temperatures with enormous savings of energy. The potential for low temperature oxidation of hydrocarbons and other gaseous contaminants is an added benefit of this new technology.

Applications

Application of this NASA technology is by no means restricted to laser technology. In fact the unique characteristics of this technology could have potential uses in several market segments. These segments are summarized below:

- Air purification at ambient temperatures (residential, commercial, transportation - Aircraft/submarines)
- Internal combustion engine exhaust gas conversion at start up/cold temperatures
- Portable breathing devices (air cartridges)
- CO-free cigarettes
- Trace gas sensors

Participants

Dr. Billy Upchurch, NASA Langley Research Center
Dr. David Schryer, NASA Langley Research Center

Company participants: To be determined

Status

RTI provided assistance to Langley to present the catalyst technology to industry through a Commercial Opportunity Program (COOPPR). RTI developed the brochure and a company list for invitees to the briefing. RTI sent the material out to over 80 companies in several industries. Each company was requested to submit statements of interest and qualifications prior to the briefing. The briefing was subsequently held for nine companies at Langley on November 2, 1994.

Companies were requested to submit commercialization plans directly to Langley.

PROJECT TITLE: **Mobile Robot Leak Detection Surveillance in the Surry Nuclear Power Plant Loop Room**

SOURCE OF OPPORTUNITY: **Virginia Power Company**

RTI Team Personnel: Stephen A. Lehrman

Background

There are numerous applications which call for a mobile robot with a dexterous manipulator arm to perform tasks in hazardous areas. These include toxic and radioactive site inspection and cleanup, hazardous materials handling, and fire fighting. The tasks to be performed range from providing video surveillance and taking measurements to cleaning operations and manipulating objects. The system needs to be portable, easily deployed, and simple to operate by field personnel.

Several large electric utilities have been developing robots for nuclear applications. There is a Utility/Manufacturers Robotics Users Group (U/MRUG). There is currently an intense effort within the nuclear industry and the DoE for robotics systems to clean up radioactive and toxic sites. All told, there have been several hundred applications of robotics devices in the nuclear industry. In general, these applications have required custom design and development of the robot for the specific need or location. Unfortunately, such activities do not help the average nuclear facility obtain a robotics system for its application or encourage the average robotics system vendor to develop a modular, user-friendly integrated system which can readily be tailored for a user's application.

Most of the technology required for a modular hardware/software system currently exists. However, the equipment has never been integrated into a complete system with a user-friendly interface. Many commercial subsystems are available, but there has been no attempt to generalize or to make them user-friendly. Consequently, obtaining a mobile robot for a specific application still involves a significant integration effort with expensive consultants and hardware/software development.

The purpose of this project is to develop a user-friendly, modular hardware/software configurable mobile robot for inspecting the Surry Nuclear Power Station loop room for leaks. The project is divided into two phases. Phase I is a six month effort to build a three dimensional CAD representation of the loop room and various mobile robot platforms to determine whether the mobile robot could operate without interference within the loop room. The second phase of the project is a 12 month effort to obtain a mobile robot platform and outfit it with an onboard computer, dexterous manipulator and sensor suite.

NASA Technology

NASA will provide the technology and expertise to CAD model the loop room and various mobile robot platforms. The objectives of the graphics simulation are:

(1) evaluate the trade-offs of various commercial systems and develop performance specifications for the mobile robot,
(2) permit Virginia Power to see how the mobile robot system will work and how helpful it will be to performing the loop room leak detection,
(3) get an early start on operator interface development, and
(4) serve as a demonstration for other potential customers such as hazardous material handling, fire fighting, and security applications.

In the second phase, NASA or Virginia Power would purchase the hardware, including the mobile robot base, the dexterous manipulator arm, sensors, communications system, batteries, and computers. NASA would be responsible for the system integration, developing the software and operator interface, and laboratory testing.

Participants

Virginia Power Company
Langley Research Center

Status

The RTI Technology Applications Team has completed a survey of the mobile robotics platform vendors and sent a final report to Ms. Cheryl Allen of the LaRC Technology Applications Group. Information was provided by Remotec, Cybermotion, Inukton Services, and AECL Candu on their respective mobile platforms. Contact was also established with U/MRUG and through this industry group with General Public Utilities (GPU) Nuclear, which operates the Three Mile Island nuclear power station. GPU Nuclear has indicated that they may be willing to donate a mobile robot, or otherwise participate, to the project.

RTI recommended that NASA and Virginia Power:

(1) meet with the mobile platform vendors and inspect their equipment,
(2) further evaluate the requirement for untethered operation,
(3) consider whether the modular hardware/software already provided by some mobile platform vendors is sufficient for this project.

PROJECT TITLE: **Negative Pressure Ventilator for Critical Care Medicine**

SOURCE OF OPPORTUNITY: **NASA Ames Research Center**

RTI Team Personnel: Daniel Winfield

Background

When medical patients reach the stage of impending respiratory failure, mechanical ventilation is used to support respiration. Early in this century, iron lungs were developed that applied a negative pressure below the neck of the patient. This negative pressure assisted the lungs in the inspiratory phase. The 1960s and 1970s saw the development of positive pressure ventilation in which positive pressure in applied in cycles through a tracheotomy tube or face mask. While positive pressure ventilation has become the accepted standard, proponents of negative pressure ventilation (NPV) still argue in favor of its potential benefits (no facemask or trach tube required, does not depress cardiac output, and does not decrease atrial naturetic factor). These benefits may be particularly important for use with pre-term, low birth weight neonates.

NASA Technology

Over the years NASA has developed tremendous expertise in the engineering of highly reliable, vacuum chambers and in the design of human life support systems. NASA Ames Research Center submitted a proposal to NASA HQ Life Sciences to apply this expertise to the construction of a neonatal negative pressure ventilator. Potential medical collaborators have been established at Stanford University and the University of Miami. The proposed project would build a negative pressure ventilator with improved pressure and temperature control, clear chamber for patient viewing, improved access ports for hands and for sensors or fluid lines.

Participants

Dr. Bruce Webbon, NASA Ames Research Center
Dr. Eduardo Bancalari, University of Miami
Dr. Ronald Ariagno, Stanford University

Status

In order to help in their evaluation of this proposed project, Robert Calloway at NASA HQ Life Sciences requested that RTI assess the market potential for negative pressure ventilation (NPV). Following a meeting with the project staff at NASA Ames, RTI performed an assessment that looked at the clinical applications and trends in mechanical ventilation, the potential market for

an NPV device, and the market penetration challenges to be overcome. RTI reviewed our findings with the project staff and completed a final report on the assessment. This report concluded that:

- negative pressure ventilation represents a small niche market at this time,
- a cadre of clinicians believe that NPV has merit, particularly for neonates,
- the larger medical community is more cautious, viewing the drawbacks to patient access as a potentially insurmountable barrier.

Due to the uncertainty of the clinical value and market opportunity for NPV, RTI recommended that, rather than take a lead role, NASA should encourage other organizations (private companies or public health agencies) to take the lead in the project and for them to access the NASA technical expertise necessary for the project. Several companies contacted by RTI expressed moderate interest, but only one, Portalung, was sufficiently interested to propose a project with NASA. Unfortunately, Portalung is a small company and is looking for NASA to provide the primary resources, including funding, for the prototype development.

PROJECT TITLE: **Optical Broadcasting Wind Indicator**

SOURCE OF OPPORTUNITY: **Kennedy Space Center**

RTI Team Personnel: Stephen Lehrman

Background

The Optical Broadcasting Wind Indicator was invented by NASA Kennedy Space Center to provide a remote display of wind speed and direction more accurately than can be attained by viewing a windvane or windsock. The device broadcasts measured wind speed and direction information via optical flashes from a high intensity strobelight collocated with the sensors.

Users at Kennedy Space Center find that accessing wind direction from up to several miles distance enables them to perform a variety of tasks more safely and efficiently than before. For example, local surface wind speed and direction is needed for:

- aircraft pilots conducting low-level operations
- on-site safety officers establishing hazard zones and safety corridors during toxic material handling
- real-time weather observations during weather sensitive field operations.

NASA Technology

The Optical Broadcasting Wind Indicator is intended for unmanned applications where greater precision or viewing distance is required than can be provided by a windsock. The instrument is not intended for commercial aviation applications where radiofrequency systems such as the Automated Surface Observation System are more appropriate. Instead, the Optical Broadcasting Wind Indicator may be used at general aviation airports and helicopter pads on buildings in metropolitan areas or at hospitals. Wind direction and speed monitoring for atmospheric plumes is another application for the instrument.

This instrument permits any number of users to determine wind speed and direction accurately from far-removed locations and without a dedicated display. Under nearly all conditions of visibility, but particularly in adverse weather conditions such as fog, haze, or rain, the practical viewing distance for a strobelight is an order of magnitude better than that for even a well-lighted mechanical wind indicator. Because the intelligence of this wind indicator is local to the sensing device, the sensor system can be designed so that it is completely self-contained, requiring no connection or wiring to other equipment.

Participants

Jim Aliberti, KSC
Jan Zysko, KSC
Ferdinand Chew, MidContinent RTTC

Status

The Optical Broadcasting Wind Indicator was developed at the NASA Kennedy Space Center, and a patent application is in process. The KSC TUO requested RTI to develop a Technology Opportunity Announcement to help locate a commercial partner to license the technology, develop a commercial prototype, conduct market testing, and, ultimately, manufacture, sell and market the instrument. The TOA was distributed by KSC at the NASA Technology 2003 conference in December.

Mr. Ferdinand Chew of the Midcontinent RTTC arranged a telephone discussion with Mr. Steve Wood, Capco, Inc., Grand Junction, Colorado. Capco manufactures products for the aircraft industry. Mr. Wood indicated that it was important to Capco that a market for the wind indicator be quantified. Mr. Chew conducted a brief market investigation for the wind indicator. Capco has stated that they are only interested in manufacturing the instrument if another company is willing to be responsible for marketing and sales.

The RTI Application Team has contacted another company, Warren-Knight Instrument Company, Philadelphia, PA that may be interested in manufacturing and selling the wind indicator. RTI sent Warren-Knight the marketing information developed by the MidContinent RTTC and is awaiting their review.

A third company, Elettronica Aster, S.P.A. of Italy has requested information on the optical broadcasting wind indicator. RTI is working with the KSC Technology Transfer Office to decide upon a course of action regarding this inquiry.

PROJECT TITLE: **Optical Measurement System**

SOURCE OF OPPORTUNITY: **Langley Research Center**

RTI Team Personnel: Daniel Winfield

Background

NASA Langley Research Center requested RTI to perform a market assessment for the Optical Measurement System, an infrared system for measuring and controlling the position and orientation of a magnetically suspended object. The system has been developed to control objects within a wind tunnel. This application demands high speed, wireless measurement of position and orientation for feedback to the magnetic suspension system. RTI was requested to investigate potential non-aerospace applications of the system.

NASA Technology

The Optical Measurement System (OMS) uses multiple linear charge coupled devices (CCDs) to detect and determine the positions of small infrared light emitting diode targets placed on the object to be tracked. Remote, wireless commands control the sequential strobing of the LEDs in order to remove ambiguity as to which LED is being viewed in any given CCD frame. Measurement of the position of these targets allows one to compute the position and orientation of the object relative to an external reference frame. Each CCD camera is controlled with a high speed digital signal processor (DSP). A central DSP is used to control data flow and to calculate the position of the rigid body in six degrees of freedom.

The OMS was designed for high speed, high accuracy, low light level tracking applications. It provides for 550 million floating point operations per second. The position of any single target is determined at a rate of 500 times per second, and the position of the rigid body is updated at a rate of 40 times per second. While this performance is impressive, it is accomplished at a price. It is unclear whether there will be commercial applications which will bear the cost associated with such high performance.

The OMS is the first known system to eliminate the hardwired connection and to make the remotely controlled LED targets sufficiently small for use on many types of objects without adversely affecting object motion. In discussions with industry, the battery-powered, remotely strobed targets are of primary interest for commercial applications.

Participants

Sharon Welch, NASA LaRC
Kevin Shelton, NASA LaRC
Walter Duncan, NASA LaRC
Greg Manuel, NASA LaRC

Status

RTI completed an initial assessment of market applications for the OMS, including motion analysis in medicine and rehabilitation, human performance measurement, motion analysis in sports, precision measurements in manufacturing, control of rigid bodies, and surface contour and displacement measurements. RTI contacted a number of the leading companies in this market to compare the OMS performance to existing products and to determine industry interest in the invention. The market for such systems is largely limited to research applications. Lower costs could open up broader markets (such as golf swing analysis), but the NASA system is at the high end of the performance-cost curve. After several discussions and conference calls, the object of primary interest is the battery-powered, remotely strobed LED targets.

Early interest was expressed by Kit Vaughn, University of Virginia. Discussions between he and the NASA inventors has led to an informal arrangement wherein NASA is providing technical guidance for a system to measure human motion in rehabilitation applications. The greatest industry interest was expressed by Pixsys, Inc. which manufactures a system for medical applications. RTI arranged discussions between Pixsys and NASA. At this point it was determined that the contractor involved in the effort, Vigyan, Inc., a small business, intended to retain rights for commercial use. However, the contractor was not involved in all aspects of the enabling invention. A second invention disclosure was submitted (with only NASA inventors), specifically covering the remotely operated, synchronously strobed LED targets. RTI provided an assessment of the commercial opportunity for this invention in July, and Langley is pursuing patent action. No further assistance from RTI has been requested since that time. The RTI assessments included listing of seven companies who may be potential licensees for this technology.

PROJECT TITLE: **Particle Fallout Monitor**

SOURCE OF OPPORTUNITY: **Kennedy Space Center**

RTI Team Personnel: C. Gary Hughes

Background

This project resulted from the process of evaluating promising technologies emerging from the operating groups at Kennedy Space Center. The existing particle fallout system was developed by NASA engineers to replace a manual method for monitoring and measuring the accumulation of dust and other damaging particles on delicate payload components. The resulting real-time system can monitor and record the fallout activity in areas in which sensitive payloads are stored. The previous NASA system used witness plates and manual microscope examination to identify particles and amounts. To provide a real-time record of the fallout, the NASA system, which is battery operated and has memory capability, was designed using commercially available components.

NASA Technology

The existing system is capable of measuring, recording with a time-tag, and downloading fallout levels in monitored areas. The system has a very low signal to noise ratio and thus excellent sensitivity. It can detect particle sizes of 0.2 microns and larger. The NASA system provides excellent results — comparable with particle counts obtained with much more expensive instruments.

The current design consists of two parts: the sensor module and the data acquisition module. The sensor module is constructed of black delrin, chosen for its optical properties. It has an opening in the top through which dust can fall and settle onto a test mirror. An infrared light-emitting diode (LED) with a limiting aperture is used to illuminate a portion of the mirror. This light is reflected by the mirror, when no dust or scratches are present. However, the light is scattered when it encounters particles or scratches. The scattered light is monitored by an optical assembly consisting of two lenses, a long pass filter to remove the effect of ambient light, and a large area silicon detector. The signal from the detector is digitized by a 12-bit A/D converter, processed, and displayed on a liquid crystal display (LCD) on top of the unit. The signal can also be transmitted to the data acquisition unit via serial communications interface.

The second part of the system is the data acquisition module. This module polls the sensor for data at selected time intervals and saves the data. The module contains a microcontroller and ramified timekeeper with 32k bytes of memory. The timekeeper enables the data to be time-tagged. The unit can be connected to any computer with an RS-232 serial port.

To improve the sensitivity of the system, the LED is turned on and off several thousand times during each sampling interval. The signal difference at the detector between the on and off states of the LED is then averaged to produce a relatively low noise signal. This process improves the system performance beyond that achievable with only the 12-bit A/D converter.

The wavelength of the infrared source is 900 nm; particles that are 200 nm and larger will scatter the light and thus be detected by the system. For this reason, the system is capable of detecting particles smaller than 1 micron. Condensables this small can also be detected as long as they stay in droplet form and do not form a sheet on the test mirror.

The particle fallout monitoring system offers the following uses:

- contamination monitoring
  - clean rooms
  - industrial applications like pharmaceutical or semiconductor manufacturing
- activity monitoring
  - medical patient monitoring
  - accumulated animal motion
  - security
- air handling assessment
  - performance assessment
  - verification

Participants

Robert Youngquist, KSC/I-NET

Company participants: To be determined

Status

In cooperation with KSC and the Technological Research and Development Authority (TRDA) of Florida, RTI organized a technology briefing which was held on April 22, 1994. TRDA works with Florida companies to develop opportunities for them to adopt NASA technologies and to produce new products in the state of Florida. Turnout was good, with a major manufacturer of particle detectors in attendance. During the presentation, the KSC technical representatives described a next generation monitor which will have a quantitative output. Those in attendance were reluctant to invest in the current technology since a more capable version was already planned. The representative of the major particle detector manufacturer did, however, examine the potential after he returned home. They offered their result — that they couldn't justify the

investment for the market size — but held out the possibility of collaborating with NASA on the next generation of particle monitor if NASA so desired.

PROJECT TITLE: **Scientists' Intelligent Graphical Modeling Assistant (SIGMA)**

SOURCE OF OPPORTUNITY: **Ames Research Center**

RTI Team Personnel: C. Gary Hughes

Background

This project resulted from the process of evaluating promising technologies supported by the NASA Operations Intercenter Work Group (Mel Montemerlo, Code CD). Researchers at Ames had a need for a scientific modeling tool that would help scientists create sophisticated models without having to do extensive computer programming of the scientific algorithms. The tool was to incorporate a comprehensive knowledge base that would form the foundation for the subsequent models. They also desired a tool that would be reusable by other scientists in the same field. The Artificial Intelligence Research Branch created SIGMA to perform these functions for two different scientific knowledge domains.

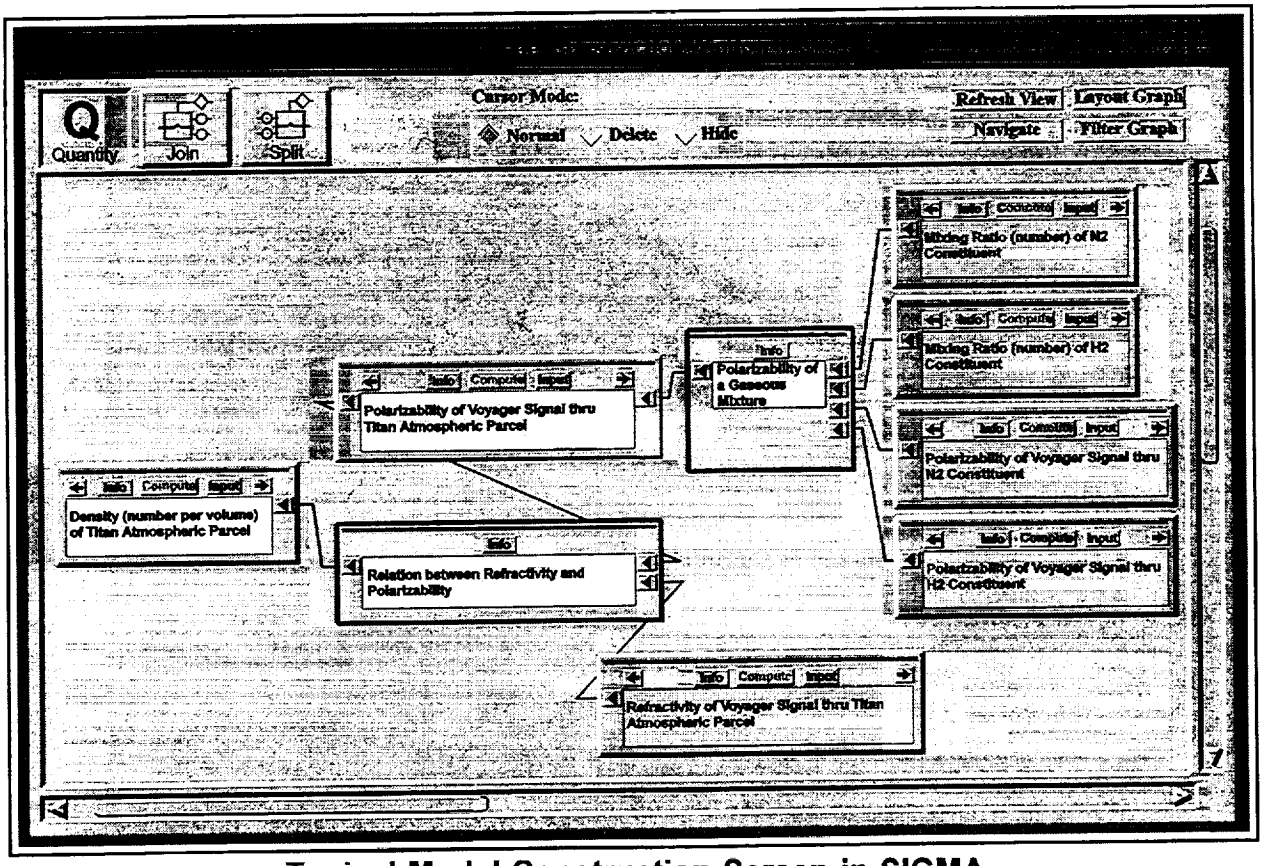
In reviewing a number of software capabilities from this branch, RTI determined that SIGMA presented a significant value for the scientific community. The potential market was queried to validate the RTI assessment and a technology marketing effort was launched.

NASA Technology

SIGMA is an interactive, knowledge-based, graphical software development environment that helps scientists to rapidly prototype their scientific models. The SIGMA tool is intended to simplify construction, modification, and reuse of modeling software, and to provide a supportive computational environment for exploratory model building. Despite the importance of modeling in the overall scientific process, scientists have little computational support available to help them perform this specific task. Recognizing this need, scientists at NASA have used representation and reasoning techniques from artificial intelligence to provide intelligent computational support for the modeler. Within the SIGMA environment, users create scientific models by configuring graphical building blocks that correspond to entities within a scientific model: equations, quantities, and datasets. The model itself is represented as a data dependency graph that illustrates how each derived model parameter is calculated from input parameters via a series of application equations.

In contrast with more conventional model building, using SIGMA is simple and intuitive. SIGMA accelerates the scientific model building process and improves the accuracy and clarity of the scientific models produced. Rather than producing obtuse, low-level modeling code, SIGMA users construct high-level graphical structures that capture the essential scientific content

necessary to understand a model. Using its extensive background scientific knowledge, SIGMA then automatically translates these high-level structures into executable computer code.



Typical Model Construction Screen in SIGMA

SIGMA's use of a high-level model specification language has many advantages. Peer review of scientific theory that is specified using SIGMA's language is much easier. Similarly, sharing of model fragments becomes more feasible when the scientific content of those fragments is readily understood and their modeling assumptions are clearly identified.

Conventional scientific modeling can be extremely labor intensive, and staffing in scientific labs is often insufficient to provide for extensive programming assistance to accomplish the necessary work in a reasonable timeframe. In addition, many scientific endeavors involve generating code that incorporates sophisticated numerical analysis techniques and other advanced programming methods that some scientists may not be equipped to handle. The high level graphical language provided by SIGMA enables the scientist to avoid these problems and to build the model without the need for learning and implementing low level code.

SIGMA incorporates a knowledge base of both general purpose and domain-specific modeling concepts that helps scientists to more efficiently specify model structure. This unique feature has

been developed to allow reuse by other scientists. It is also designed to allow users to add different modeling concepts that are appropriate to modeling of problems in their own scientific investigative areas. The NASA SIGMA knowledge base currently incorporates over 1000 concepts that encode a variety of types of knowledge:

- information about scientific equations,
- physical quantities,
- constraints,
- conversion factors for scientific units,
- numerical programming methods,
- scientific domain concepts, and
- bibliographic citations.

Participants

Rich Keller, ARC

Company participants: To be determined

Status

The technology briefing drew three companies. The major players in scientific modeling software chose not to attend. The result of this effort was the validation of the capability as a worthwhile advance in the state of the art. However, the candidate companies are extremely involved with modifying their systems with other needed improvements. They could not justify exploring SIGMA because they do not have sufficient time or resources to follow through on product changes already in the pipeline.

PROBLEM TITLE: **Spiral Fluid Separator**

SOURCE OF OPPORTUNITY: **Marshall Space Flight Center**

RTI Team Personnel: Doris Rouse, Laura Schoppe

Background

In early September, 1994, Mr. Tony Robertson, a MSFC engineer, contacted Dr. Doris Rouse requesting assistance in finding a commercial partner for his patented Spiral Fluid Separator (USP 5,248,421). The following summarizes RTI's efforts:

- Mr. Jerry Seemann, MSFC Patent Attorney, provided a list of companies that had requested information on the patent. RTI contacted, via phone and letter, those companies that had inquired about licensing this technology.

- Discussions with Mr. Joe Resnick, Petrol Rem, to determine the validity of his interest in Mr. Robertson's invention, revealed that he was interested but required funding approval by his partner Fred Cooper, Bio Control Tech. Several weeks later, Mr. Resnick stated that Mr. Cooper did not wish to pursue this technology because R&D funds were already committed. Additionally, Mr. Resnick confided that they had another similar technology that they would pursue in the new fiscal year, rather than the Spiral Fluid Separator.

- After several discussions, another interested party was identified. Mr. Charles Humphrey is starting his own company, GeoSpace Technologies, Inc., to exclusively pursue building a prototype of the Spiral Fluid Separator with the intention of creating a commercial product.

- Mr. Humphrey has been notified to contact Mr. Seemann to establish the proper licensing arrangement, followed by a formal written request. Mr. Humphrey was also advised to contact the Technology Transfer Office to discuss potential cooperative development efforts with MSFC.

NASA Technology

The Spiral Fluid Separator is a patented technology for the separation of particles in a fluid mixture. The concept is ideal for waste water management and petroleum applications.

Participants

Research/Inventor	Glen A. Robertson
MSFC Technology Transfer	Harry Craft
MSFC Patent Office	Jerry Seemann
Research Triangle Institute	Dr. Doris Rouse
	Laura A. Schoppe
Potential Licensing Partner	GeoSpace Technologies

Status

A licensing agreement is being developed between MSFC and GeoSpace Technologies.

PROJECT TITLE: **Super-Resolved Image Processing Software (S-RIPS)**

SOURCE OF OPPORTUNITY: **Ames Research Center**

RTI Team Personnel: C. Gary Hughes

Background

This project resulted from the process of evaluating promising technologies supported by the NASA Operations Intercenter Work Group (Mel Montemerlo, Code CD). Researchers at Ames developed the Super-Resolved Image Processing Software (S-RIPS) as a cost-effective way to improve the quality of images from space probes. It solves image quality problems by creating one super-resolved image from several images. As the number of digitized source images increases, the software produces even better quality final images.

RTI determined that S-RIPS presented a significant value for the imaging community. The potential near term markets range from earth observing satellite imaging to medical applications such as ultra-sound imaging. The technology is ready to perform in applications requiring image enhancement of still photos, where a number of digitized photos can be provided as input to the process. Real time processing and full motion image processing are projected to be in the realm of possibility as the technology matures.

NASA Technology

Image quality is affected by distance, object/camera orientation, environmental conditions, and camera quality. It is often impractical to try to overcome these problems with a better camera, a better vantage point, or changes in conditions.

Super-Resolved Image Processing Software (S-RIPS) uses a number of source images of the same object (but from slightly different perspectives) to make a final image of higher quality. Both spatial and gray scale resolution are improved. Four source images will result in a final super-resolved image with double the resolution of the original images. Sixty four images will yield eight times the resolution in the final product.

Any set of digitized images of the same area can be processed. Only the digitized images and the software are required. However, additional information, such as knowledge of the camera characteristics, can speed the processing. This research code currently runs on Symbolics Lisp machine.

The research code is not optimized for speed. It does contain a routine that, when fully implemented, will bring still more clarity to the super-resolved image. By using a statistical

routine based on Bayes Law, the software will provide for better contrast, sharper detail and smoother transitions in areas of insufficient information.

Potential Applications can be described as follows:

Near Term Applications: Graphic and design software, electronic prepress, image editing, satellite imaging, fax machines, scanners, security surveillance cameras, and newspaper wirephotos.

Intermediate Term Applications: Ultrasound material inspection. Since the technology has the potential for constructing 3D images, it would be feasible to check dimensional conformance of 3D objects to design specifications.

Longer Term: Full motion, real time high definition television. Higher quality teleconferencing at lower cost.

Participants

Peter Cheeseman, ARC
Robert Kanefsky, ARC

Company participants: To be determined

Status

Marketing of S-RIPS began in earnest in August, 1994. Two forms of the Technology Opportunity Announcement were developed and mailed out. The RTI standard two sided color flyer and a new form — a multi-media presentation on diskette — were sent to companies in the remote sensing and digital imaging industries. In addition, the technology was described in NASA's *Innovation* newsletter. The response to the announcement was quite impressive. As a result, two remote sensing companies are actively evaluating S-RIPS as a possible commercial tool to use for enhancing satellite images of the Earth. Other companies expressed interest in applications such as ground penetrating radar — for identifying sources of ground contamination, and infrared imaging of aircraft materials suspected of internal damage or hidden corrosion.

PROJECT TITLE: **Supersonic Gas-Liquid Cleaning System**

SOURCE OF OPPORTUNITY: **Kennedy Space Center**

RTI Team Personnel: C. Gary Hughes

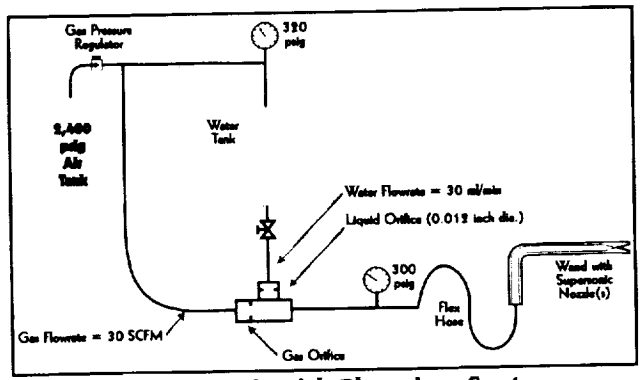
Background

This project resulted from the process of evaluating promising technologies emerging from the operating groups at Kennedy Space Center. This particular invention was driven by the mandate to replace chorofluorocarbon (CFCs) solvents at the Center. The existing method for cleaning and cleanliness verification of critical hardware used copious quantities of freon for rinsing. The system uses the high momentum of a supersonic air-liquid jet to remove contaminants from components while simultaneously emulsifying those contaminants into the liquid (typically water). The liquid is collected and sampled for contaminants to verify cleanliness. Extremely low volumetric flow rates of liquid are required with this system.

NASA Technology

The Supersonic Gas-Liquid Cleaning System was developed by NASA engineers to replace CFC-113 rinse cleaning and cleanliness verification methods. Equivalent or better performance of the new technique was verified by extensive testing using common contaminants (e.g. hydraulic oil and various greases) where removal efficiencies of better than 90% were achieved using air and water. The cleaning system uses less than 100 milliliters of liquid per square foot of cleaned surface area in its current configuration. Also, the operating pressure of 300 psi for this system is quite modest in comparison to other pressure-based systems. Used liquid can be collected for cleanliness verification.

The system (shown in the diagram) generates a supersonic gas-liquid stream that is directed at the surface to be cleaned. The high velocity of the mixture as it impinges on the surface has sufficient momentum to dislodge contaminants and emulsify them into the cleaning liquid. The liquid continuously drains off leaving a clean surface. After a surface has been cleaned, the liquid supply may be turned off in order to use the pure gas stream as a drying agent.



Supersonic Gas-Liquid Cleaning System

The inventors of this system, engineers from Kennedy Space Center and its contractor, I-NET, received the NASA Space Act Award in September, 1993 for their work.

Participants

Greg Melton, KSC
Eric Thaxton, KSC
Raoul Caimi, KSC
Dave Makufka, KSC

Company participants: To be determined

Status

A Technology Briefing was held on February 4, 1994. The Technological Research and Development Authority (TRDA) of Florida participated with this briefing and hosted the meeting at their facility. Two companies from outside of Florida attended and about five others wanted additional information but could not attend. One of the attending companies subsequently revisited KSC to have a sample cleaned. They were impressed with the capability but are not in a position to commercialize the technology. They will be interested in the system for their own use.

KSC has received four commercialization plans. One was submitted by the TRDA after they selected a Florida company. The selection of commercial partners has been on hold for over six months. KSC is working on the definition of the dual use role for the technology — cleanliness verification of transport tankers. The central issue is whether or not these tankers require 100% coverage for cleanliness verification after precision cleaning has occurred. If so, a dual use project may not be possible since the cleaning system would be impractical for this use. While KSC works through this decision, the Technology Utilization Office and the TRDA have commissioned a characterization study of the supersonic nozzle at the University of Florida.

PROJECT TITLE: **Temporal Directed Acyclic Graph (TDAG) Flexible Sequence-Learning Algorithm**

SOURCE OF OPPORTUNITY: **Ames Research Center**

RTI Team Personnel: C. Gary Hughes

Background

This project resulted from the process of evaluating promising technologies supported by the NASA Operations InterCenter Work Group (Mel Montemerlo, Code CD). Researchers at Ames have been studying ways to predict sequences based on probability theory. They studied a number of techniques and have found that the Temporal Directed Acyclic Graph (TDAG) algorithm can be a powerful tool to solve sequence prediction problems.

Efficient sequence prediction is very useful in a broad range of applications. For human-computer interface design, online documentation systems, database query optimization, intrusion detection systems for computer networks, and even for word processing in languages such as Japanese, prediction techniques can provide remarkable increases in speed and efficiency.

NASA Technology

TDAG is a simple and practical algorithm that learns to predict sequences of discrete events. The task for discrete sequence prediction is to find statistical regularities in an input sequence so that, at any time, the next few input parameters can be predicted with better-than-chance likelihood. The TDAG technique has been refined to be fast, efficient, and highly adaptive to changes in the input.

TDAG has a number of potential uses. In three published demonstrations, TDAG was used as a predictive caching routine to reduce database access time, a technique for dynamic optimization of Prolog programs, and as a text compression algorithm.

Disk caching is one way to reduce access times for mass storage devices. Small amounts of data can be stored temporarily in a high-speed storage cache while the bulk of the data remains on a mass storage system (MSS), usually disk or tape. Intelligent caching enables the cache manager to predict which portions of the data are most likely to be needed soon, and thereby to manage cache so that data transfer to and from the slower mass-storage device is minimized. The TDAG is ideal for predictions like these and is vastly superior to conventional predictive techniques like least-recently-used (LRU). Experiments clearly showed how TDAG can reduce access times for fetching data. As Table 1 shows, the TDAG routine outperformed the LRU algorithm by 23%

to 92% even without using TDAG's prefetching capability. With prefetching, TDAG reduced secondary memory accesses by an additional 16% to 90%.

	Case 1	Case 2	Case 3
Number of Users	10	6	2
Segments per User	3	5	15
Total Requests per Run	30000	30,000	30,000
Mean Waiting Time (LRU)	15.21	10.29	5.63
Mean Waiting Time (TDAG)	11.74	3.8	5.63
Waiting Time Reduction	0.23	0.63	0.92
Prefetch Fault Reduction	0.16	0.57	0.9

Table 1 - Sample Results - Disk Caching and Data Retrieval

The second demonstration involved implementing a TDAG **dynamic optimizer** for Prolog programs. Prolog is a language widely used for artificial intelligence applications. A dynamic optimizer restructures a program while it is in use so that it may run faster for the types of inputs that it sees most often. For Prolog programs, the TDAG-based optimizer learned to predict the results of choices (search) and restructured the program to first try those candidates with the greatest likelihood of success. The result was an equivalent Prolog program with better average performance. In this application, TDAG was used instead of a traditional Markov chain because of its superior ability to predict sequences in context.

Comparisons were made of average program performance before and after dynamic optimization using TDAG. The improvement for several types of Prolog routines is shown in Table 2. The results confirm that the TDAG-based dynamic optimizer can boost performance of certain types of programs.

Program	Average Improvement (%)	
	CPU Time	Unifications
CF Parser	41.1	34.5
Membership List	18.5	17.2
Logic Circuit Layout	4.8	9.5
Graph, 3-Coloring	0.2	-1.4

Table 2 - Sample Results - Dynamic Optimization

The **text compression** experiment was a quick test (put together in about an hour) in which TDAG predictions were combined with a Huffman code to compress several different text files. Performance, as measured by the text compression ratio, was then compared with two commercially available Unix routines: "*compress*" and "*compact.*" The unoptimized TDAG compression performed as well or better than the commercially available routines.

In each of the three previously described experiments, the TDAG algorithm was adapted and integrated into the application. In general TDAG will be most effective when customized as part of a system instead of being viewed as a library routine. The algorithm is rather simple, so that customizing it for each application is feasible.

TDAG represents a key step forward in the science of Computer Learning. Adaptations of the technique will benefit many applications by speeding up and simplifying operations and by reducing the resources required to execute programs and store information.

Participants

Phil Laird, ARC

Company participants: To be determined

Status

The initial thrust for this technology was intended to take advantage of the ability of the routine to improve the performance of disk caching for retrieval of data from mass storage devices. Investigations of these markets found very little support. From high performance hard drives for personal computers and workstations to large disk farms for online services, disk caching is not a significant problem. The technology opportunity announcement was made available through NASA's *Innovation* newsletter. Three requests for information were received from that announcement. Also, several companies were selected for direct mailing of information on

TDAG. The best prospect for an application that RTI identified was the company that is responsible for the next generation of distributed computing environment (DCE). That company, Transarc (Pittsburgh), performed a detailed assessment of the use of TDAG to enhance the efficiency of disk caches which handle many requests for large amounts of data over the DCE system. They determined that the TDAG approach would provide an incremental improvement. However, the TDAG approach did not make the final cut for implementation. Transarc had several hundred improvement schemes for various features of the new DCE system, and had insufficient time and resources to pursue them all.

Other markets are also being explored. One company in California is quite interested in TDAG for several projects they have or are contemplating.

PROBLEM TITLE: **Turbine Brush Pipe Cleaner**

SOURCE OF OPPORTUNITY: **Kennedy Space Center**

RTI Team Personnel: Daniel Winfield

Background

Pipe cleaning is important in almost every industrial location because internal build-up of contaminants restricts flow and increases power required to force fluid through the line. Reduced product purity and internal corrosion can result. While there are a number of commercially available methods for pipe cleaning, no single method works best in all applications. A NASA Kennedy employee recently invented a Turbine Brush Cleaner which is able to traverse multiple 90 degree turns in small diameter pipes.

NASA Technology

The Turbine Brush Cleaner uses a small turbine and bearing assembly which utilizes the upstream pressure of the aqueous cleaner solution to spin a standard circular brush used to clean the inside of pipes/tubes. Since the turbine brush uses the fluid through the pipe for power, a thin cable to control brush position replaces the mechanical drive cables or pneumatic or hydraulic pressure lines used to power previous systems of this type. The reduced friction of this thin cable allows the turbine brush to maneuver through t-sections and elbows over long distances. The enhanced cleaning action afforded by the turbine brush eliminates the use of chlorofluorocarbons, such as CFC-113, which harm the Earth's ozone layer. The system also provides for recycling of the water based solution used for cleaning.

The prototype system was designed for a 2" diameter pipe section, 100 ft. in length. Typical flow and pressure requirements are 100 gal./min. at 10 psig. In this configuration, the system easily traversed 90 degree bends and proved effective in cleaning pipe surfaces. While there are no theoretical limits to pipe size, larger diameters will require increasingly greater flow rates; thus the system is most applicable to small diameter pipes.

Participants

Rudy Werlink, KSC
Jim Aliberti, KSC

Status

The NASA Kennedy Space Center requested RTI assistance in transfer of the Turbine Brush Cleaner process into commercial application as a pipe cleaning system. NASA seeks a company for licensing or cooperative development to use this technology in commercial applications. The Turbine Brush Cleaner was developed to achieve a high level of cleanliness in pipes with limited or moderate levels of contamination from oils or greases. It will be directly applicable to similar uses in industry. In addition, with optimized selection of brush material and solvent/cleaners, the system may work effectively to clean pipes subject to greater levels of contamination from dirt, sludge, scale, or other mineral deposits. Areas of possible commercial application include:

Periodic maintenance of water supply lines
In service cleaning of food processing and/or pharmaceutical equipment
Removal of "milkstone" from dairy lines
Corrosion control in steam service lines
Removal of marine organisms from seawater lines
Post-construction clean-up of new pipes

RTI developed a Technology Opportunity Announcement for the Turbine Brush Pipe Cleaner. The Announcement was distributed by NASA KSC at the Technology 2003 Conference. Following the conference RTI contacted NASA KSC to determine what contacts they made and what action we are to pursue. The KSC TUO will review the contacts from Technology 2003 with the inventor and get back to RTI with requested action.

5.0 STATE-LEVEL INDUSTRY ANALYSIS

Purpose

Establishment of strategic partnerships between state and local industry sectors and NASA's Field Centers can build ongoing access for industry to NASA technology. To effectively develop these partnerships in Alabama, Marshall Space Flight Center (MSFC) requested that RTI adapt to the State-level similar mechanisms used to identify industry-wide needs at a national level. In response to this request, RTI gathered and analyzed Alabama employment data to identify major industry sectors. More data were analyzed to determine the competitive position, market climate, and technology requirements of those sectors. The result of this analysis helps MSFC:

- leverage their industry outreach resources;
- focus laboratory resources on high-impact, industry-wide needs in Alabama; and
- establish ongoing strategic partnerships with industries important to the State.

Also, this approach can be used in other States where MSFC has agreements in place to offer technology transfer assistance.

Approach

RTI developed a cost-effective, quantitative approach to help MSFC identify technology transfer opportunities in Alabama by merging three significant resources at RTI: 1) proven approaches to transfer Federal technology to national, high-impact industry needs; 2) demonstrated capabilities to conduct effective industry needs analyses; and 3) internationally recognized team of economists, statisticians, computer specialists, and business analysts who conduct State and local economic impact analyses and forecasting studies for government and industry clients.

RTI's approach to meeting the MSFC request can be broken down into three phases as described below:

1) Conduct a strategic audit of Alabama's economic base and identify key industry sectors.

Here, RTI analyzed at least three major manufacturing sectors within different political boundaries of Alabama. Criteria for identification of "major" sectors were employment levels, trends, and projections. These data were graphically presented by political boundary (i.e., by State, U.S. Congressional District, and by county — see example map and chart at end of this section).

2) Identify and assess Alabama's major industry sector(s) that promise continued development.

Here, one manufacturing industry sector was identified for a more detailed analysis. This analysis included: 1) size and economic impact of the industry within Alabama; 2) strength of supporting and/or complementary industries in the State; 3) recent legislative/regulatory requirements on the industry; 4) prior/ongoing efforts to acquire new technologies; and 5) interest of industry sector in participating in the technology transfer program.

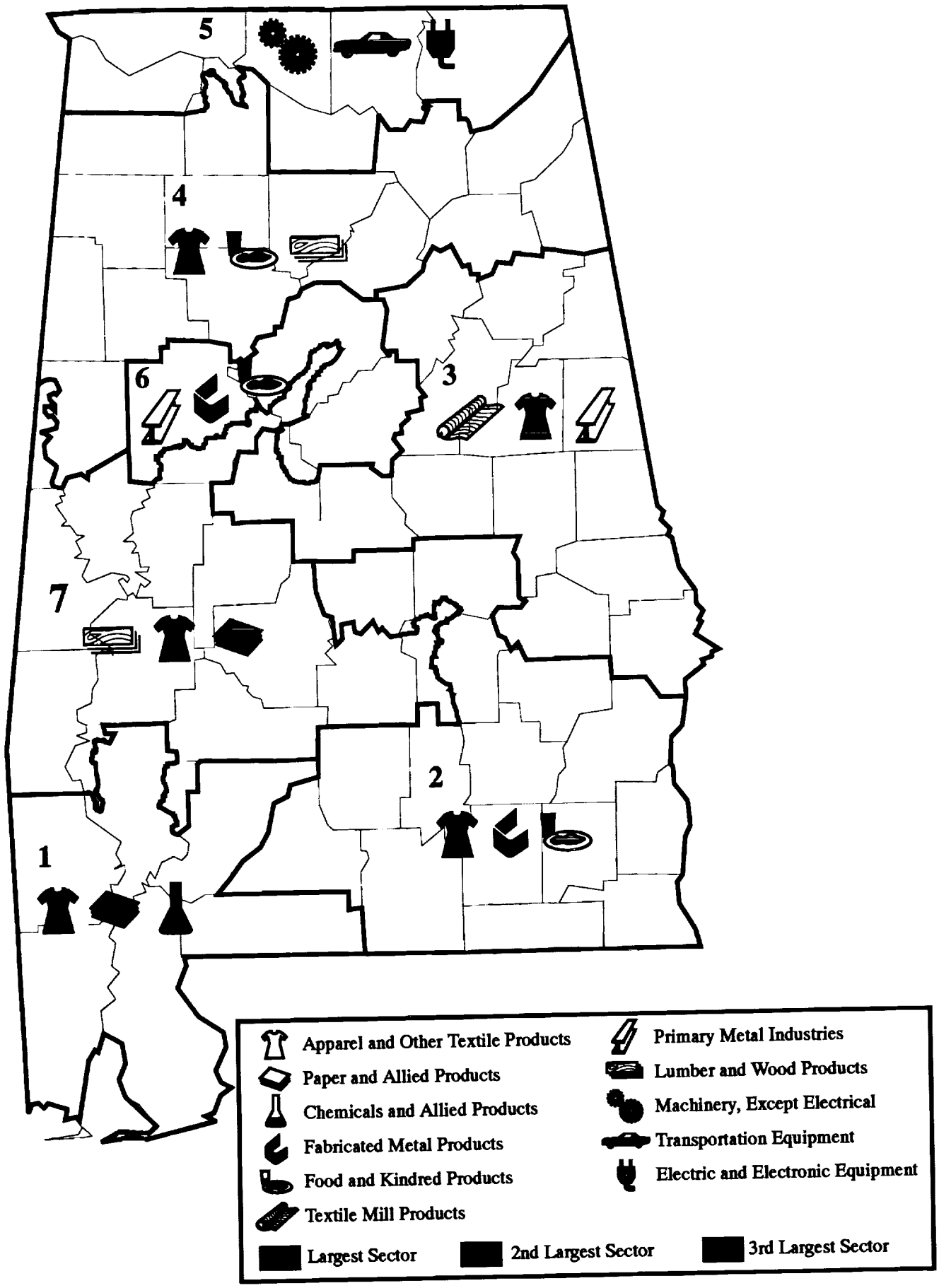
3) Assess the potential of matching industry sector needs to MSFC technology.

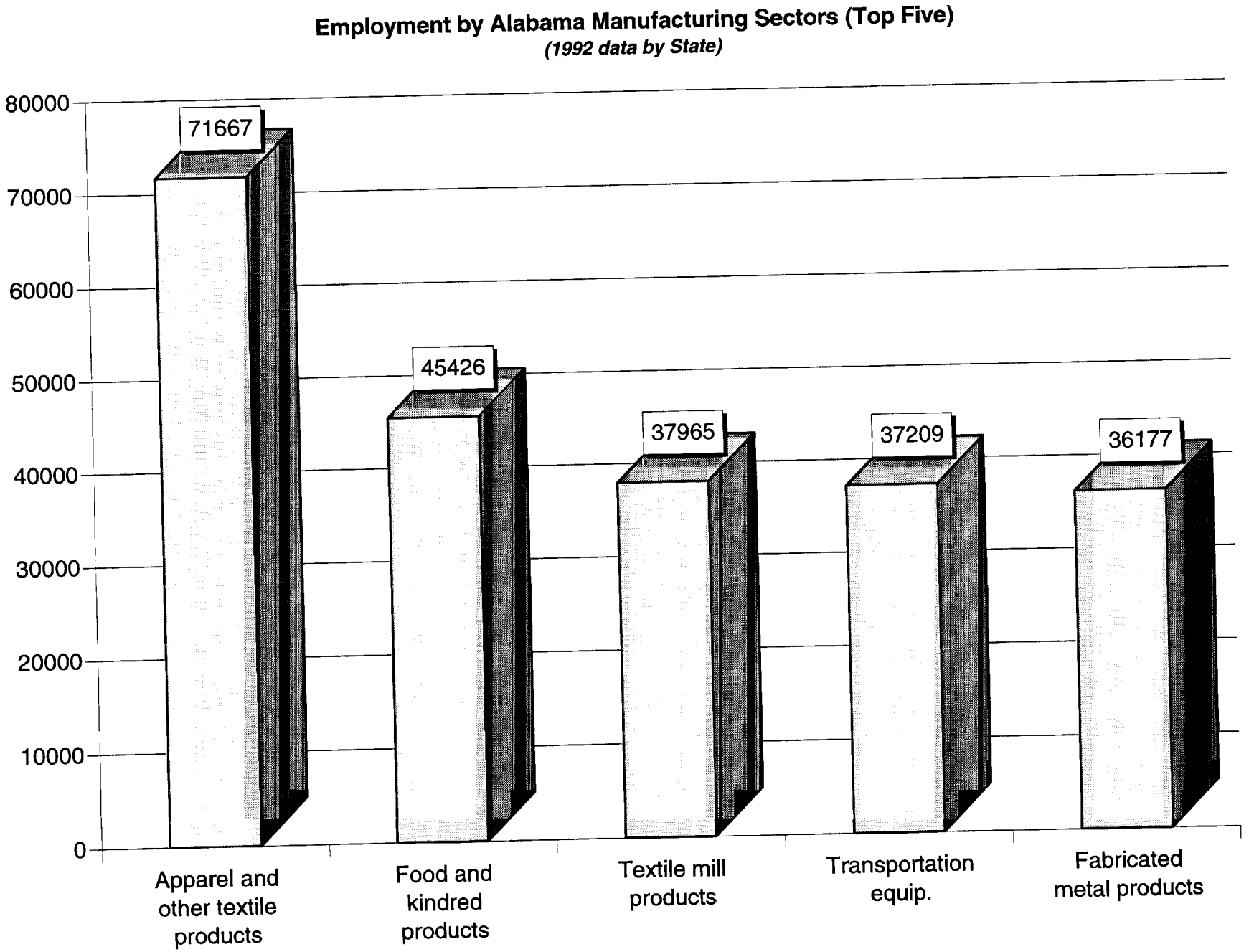
Here, RTI gave a general overview of significant industry needs. This step involved a detailed needs analysis and the presentation of possible approaches to match the needs with MSFC technologies. One possible approach presented was a Commercialization Workshop to: 1) review the described industry needs; 2) review suggested MSFC technologies; 3) build consensus among industry sector companies that MSFC technology can help them; and 4) plan projects that develop and transfer the technologies to industry.

Summary

This task serves as a first model for conducting industry analyses at a State level. As with all new processes, lessons will be learned and improvements will be incorporated. As the process evolves, RTI hopes to offer this service to other NASA Field Centers as another innovative approach to commercialize NASA technologies.

Major Alabama Manufacturing Sectors
(by Congressional District)




Employment by Alabama Manufacturing Sectors (Top Five)
(1992 data by State)
80000
70000
60000
50000
40000
30000
20000
10000
0
71667
45426
37965
37209
36177
Apparel and other textile products
Food and kindred products
Textile mill products
Transportation equip.
Fabricated metal products

6.0 COORDINATION OF ONGOING PROJECTS

PROJECT TITLE: **Contextual Alarm Management System (CALMS)**

SOURCE OF OPPORTUNITY: **National Special Education Panel**

RTI Team Personnel: Dean Hering, Dan Winfield

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 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 staff and the company legal to develop the Space Act Agreement which was signed by both parties in 1993. Subsequent to this signing, the Company entered into a contract with Dr. Feldman to support his portion of the project. RTI participated in a project kick-off meeting at JSC in August 1993 to finalize task assignments and schedules.

RTI assisted in discussions between NASA and the company to clarify the interim objectives to be completed by July 1994. The NASA project team visited the Company in April for detailed technical discussions on the AI implementation. Cooper Hospital has been identified as a data collection site. The User Interface Phase I has been developed and implemented. Although progress is being made, the project is substantially behind schedule.

PROJECT TITLE: **Digital Mammography System**

SOURCE OF OPPORTUNITY: **National Cancer Institute**
Diagnostic Imaging Research Branch

RTI Team Personnel: Daniel Winfield

Background

In 1993 approximately 186,000 women were diagnosed with breast cancer and 47,000 women died. 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
James Janesick	Jet Propulsion Lab
James Walker	Nanoptics, Inc.
Eric Fossum	Jet Propulsion Lab
Bruce Griffing	General Electric
Tumay Tumer	Nova R&D
Martin Yaffe	University of Toronto

Status

The RTI Applications Team organized and chaired a Digital Mammography Workshop in Bethesda, MD on May 19-20, 1993 to perform a more in-depth evaluation of the application potential of each technology and involve the medical device industry to begin forming partnerships for development. 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.

In September 1993, the NCI-NASA Work Group decided to issue a joint NCI-NASA Program Announcement for Federal Technology Transfer to Digital Mammography. The Program Announcement was written and received final approval in October, and was published in the *NIH Guide* on December 17, 1994.

Twenty five (25) proposals were received by NIH and forwarded to a NIH Study Section for peer review. At the request of NCI, RTI organized a meeting at NASA HQ for General Electric to present their x-ray imager project (involves JPL) and to explore potential dual-use applications. Potential dual-use has been identified within NASA Life Sciences and the NASA Solar Physics program. Two projects have been approved for funding by NCI and NASA:

1. JPL and Nanoptics, Inc. will build a CCD-based imager.

2. Nova R&D, Inc. and the University of Toronto will build and test a prototype silicon pixel detector.

A third project has been supported by NASA Code CD directly. In this project, JPL will design and build the read-out electronics for an amorphous silicon detector array developed by General Electric.

A fourth project has been funded directly by Code UL for NASA Ames to work with the University of South Florida to test algorithms developed under the Search for Extraterrestrial Intelligence (SETI) project. RTI assisted Code UL by reviewing and commenting on the proposal.

A paper on this model partnership was presented by RTI at the Technology Transfer Society Meeting, June 22-24, 1994 in Huntsville, Alabama. The program was also presented by RTI to an HHS/NCI planning conference in July. RTI also generated text and viewgraphs for Dr. Joan Vernikos, Code UL, to present this program to a Congressional Briefing in October 1994.

PROJECT TITLE: **Early Language Intervention System (ELIS)**

SOURCE OF OPPORTUNITY: **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 status of the project has not changed during the past year. LLS has submitted numerous SBIR proposals to the National Institute of Health. All of the proposals included using the ICAT software for intelligent tutoring. LLS has been notified that their proposal "Software for Verb Based Early Langley Intervention" will probably be phase I funded in April, 1995. The goal of the proposal is to develop a CD-ROM based product. LLS has been waiting for a definitive product to introduce the ICAT software before performing additional work with JSC. Now that LLS expects to have a project to develop the product, they are ready to renew their collaboration with JSC.

PROJECT TITLE: **Fetal Heart Rate and Fetal Movement**

SOURCE OF OPPORTUNITY: **NASA Langley Research Center**

RTI Team Personnel: Daniel Winfield

Background

Improved passive sensors, such as microphones and accelerometers, are needed to incorporate into an ambulatory fetal monitoring unit for use in high-risk pregnancies. A passive sensor, such as a microphone array, is needed to listen for the fetal heart rate. However, the mother's heartbeat as well as other bodily sounds and environmental sounds are superimposed on the sound of the fetal heartbeat. Recent advances in signal processing technology allow the use of autocorrelation techniques to identify the fetal heart rate from this complex signal. Experiments to date indicate two frequencies that correlate highly with the fetal heart rate -- 30 Hz and 120 Hz.

NASA Technology

Acoustics experts at NASA-LaRC have used polyvinylidene fluoride film as a piezoelectric sensor for fetal heart sounds and fetal movement. The sensor was developed in-house at LaRC with signal processing developed at Old Dominion University.

Participants

- Dr. Allan Zuckerwar, NASA-LaRC
- Dr. Donald Baker, Spokane, WA
- Dr. James Stoughton, Old Dominion University

Status

Several prototype belts incorporating PVDF microphones have been fabricated. The spectral analysis algorithms have been developed by Old Dominion University. An optoelectronic isolation connector to preclude any possible shock to the wearer has been built. Clinical testing led to refinements in transducer design to easily locate the fetal heart sounds and to eliminate 60-Hz pickup in the signal. Digital adaptive filtering will be used to eliminate movement artifacts and to focus on the frequencies of interest (30 and 50 Hz).

In FY94, NASA LaRC asked RTI to conduct a market assessment for this technology. RTI provided a report that assessed the market potential and identified several important strategies to successful product introduction. The report was sent to Veatronics, Inc., a prospective licensee, in addition to LaRC.

PROJECT TITLE: **Fiber Optic Cataract Probe**

SOURCE OF OPPORTUNITY: **NASA Lewis Research Center**

RTI Team Personnel: Daniel Winfield

Background

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 Cataract 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.

NASA Technology

The device was invented by NASA Lewis Research Center and State University of New York at Stonybrook as a rugged and compact sensor for space microgravity experiments (funded by Code UG). Dr. Ansari of NASA Lewis decided to pursue the idea of cataract detection. 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.

Since there is currently no treatment to halt or delay cataract formation, the device would not have immediate clinical application. However, it would be useful for research purposes and perhaps for clinical use in the future. Initial tests of bovine and explanted human eyes showed promising results for the probe.

Participants

- Dr. Rafat Ansari, NASA LeRC
- Dr. Harbans Dhadwal, SUNY - Stonybrook
- Dr. Michael DellaVecchia, Will Eye Hospital
- Dr. Robert Sperduto, National Eye Institute

Status

After seeing a conference publication by NASA on the Fiber Optic Cataract Probe, RTI contacted the LeRC TUO, who expressed interest in our helping to determine if the National Eye Institute (NEI) might be a good partner for development and testing. After reviewing the technology's capabilities and development status, RTI contacted the National Eye Institute which confirmed their interest in this type of technology particularly as it related to an on-going study of the epidemiology of cataract. RTI organized a meeting in Feb. 1993 at NEI for NASA to present the technology to several NEI researchers who were quite knowledgeable of other methods for making quantitative measurements of cataracts. NEI indicated they did not have funding for prototype development, but once the prototype was developed and tested, they would like to include it in their multicenter study of cataractogenesis.

Since no funding was available from NASA for prototype development, RTI developed a Technology Opportunity Announcement and distributed it to 17 companies in the ophthalmic instrument market. Two companies, Meridian and Woodlyn has expressed interest. The former is a Swiss company but has expressed willingness to manufacture in the U.S. The latter is a small business with strong marketing presence but little in-house development or manufacturing resources. Since neither of these companies was felt to be a strong commercial partner, NASA turned internally to look for sources of funding.

NASA Code UG has committed $100K to support prototype development. A prototype has been developed and animal testing performed successfully. Dr. Michael Dellavechia will obtain Institutional Review Board approval for initial clinical tests with the prototype. Once clinical tests results are available, we will be in a better position to negotiate with NEI to conduct large scale tests and with industry players for licensing and commercial development.

PROJECT TITLE: **Gamma Ray Collimator**

SOURCE OF OPPORTUNITY: **Stennis Space Center**

RTI Team 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 tens 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

- Dr. Mike Gavini, Instrument Marketing Services

Status

The Applications Team worked with the Stennis Technology Utilization Office to perform a market analysis for the gamma ray collimator. Stennis loaned to RTI a report purchased from Frost & Sullivan regarding the nondestructive testing marketplace. Using this report, information from Thomas Register, and the Corp Tech database, RTI compiled a list of companies that manufacture or use similar test equipment. RTI sent these companies a letter describing the gamma ray collimator and explaining that NASA was interested in licensing the technology. Instrument Marketing Services Company (IMS) responded to the mailing and contacted the Marshall Space Flight Center legal counsel regarding licensing the gamma ray collimator.

The Applications Team assisted IMS prepare its license application to Marshall. The Applications Team reviewed an early draft of the applications and counseled IMS on how to organize the application to facilitate NASA's review. IMS submitted the application to Marshall in March, 1994. The Marshall Patent Counsel notified IMS in April, 1994 that they were recommending that IMS receive an exclusive, worldwide license to manufacture and market the gamma ray collimator. As of December, 1994, IMS is awaiting the final contract from Marshall.

PROJECT TITLE: **Ice Detection and Thickness Measurement System**

SOURCE OF OPPORTUNITY: **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

RTI assisted JSC and RIMtech with contacts and meetings with the Federal Aviation Agency, Strategic Highway Research Program, Department of Transportation, and the Federal Highway Administration. A number of articles resulted from this exposure and presentations at several conferences. After RTI completed a state-of-the-art review for aircraft and highway applications of ice detection systems, the way was cleared to put together a collaboration between the developers and JSC to grow the technology and bring it to a point where it could be brought to

market. Industry committed 85% of the required funding ($960,000) and looked to NASA for co-funding which would result in a 5.7 to 1 leverage of NASA funds.

NASA funding for this work was approved for FY94. The Space Act Agreement was awarded to Raton Technology Research (RTR), a company spun off by RIMtech to develop the ice detection technology (now called KELVIN) and associated markets. Including FY93 money, JSC has committed to $74,000 to the effort. FY95 funding is not yet firm. RTR has continued to develop the technology during the interim, prior to the Agreement. They have also continued to promote the technology in both aircraft and ground transportation markets.

Everything is on "go." Technical work is proceeding on design specs, displays, antenna design, microcircuit design and testing. RTR continues to market the technology to aircraft companies and airlines. The development contract was finalized about April 1, 1994. The design is progressing nicely. All concepts have been demonstrated; testing and analysis are complete. Required sensor patterns have been worked out. Reducing the hardware to the final miniature design is underway.

The airline industry market is still questionable because of FAA resistance. FAA (as well as United Airlines) favors a laser scanning system. USAir, Lockheed, and others favor the RTR approach.

PROJECT TITLE: **Measurement of Cleanliness of Printed Circuit Boards**

SOURCE OF OPPORTUNITY: **National Center for Manufacturing Sciences**

RTI Team Personnel: Stephen A. Lehrman

Background

New instrumentation is needed to perform repeatable, quantitative measurement of contaminant type and quantity on printed circuit boards.

The National Center for Manufacturing Sciences has initiated a project titled *Definition and Measurement of Clean - Electronic Components*. The project team consists of representatives from Texas Instruments, Ford, AT&T, General Motors/Delco, General Motors/Hughes, and Sandia National Laboratory. The purpose of this project is to develop an industry standard test method and the associated instrumentation to measure organic and inorganic residue contaminating the surface of printed circuit boards. The end goal of the project is to develop an online, assembly line, inspection system for acceptance of finished boards.

NASA Technology

Optically Stimulated Electron Emission (OSEE) is a nondestructive, noncontact surface contamination detection system capable of detecting thin layers of contamination on conducting surfaces. OSEE equipment has been used to inspect solid rocket motor critical bonding surfaces for contamination. The OSEE phenomenon, which uses photoelectron emission, is caused when ultraviolet light is incident on the specimen surface. Photoelectrons released from the surface are measured. The signal from the surface may increase or decrease depending on the type and thickness of the contaminant. Sensitivity measurement needs to be performed for each type of contaminant. Marshall Space Flight Center and Langley Research Center have worked with OSEE.

Participants

- Tom Yost, NASA Langley
- Chris Welch, NASA Langley
- Mike Wixom, NCMS
- Carole Ellenberger, Texas Instruments
- Urmi Ray, AT&T Bell Labs

Status

Dr. Chris Welch and Dr. Tom Yost successfully demonstrated that OSEE could discriminate contaminants on non-conducting surfaces. Langley developed a dose-response curve for the insulating portion of the printed circuit board. The industry participants concluded that OSEE was sensitive enough to provide a quantitative measurement of surface cleanliness. Drs. Welch and Yost reported their findings in a paper presented at the American Society for Nondestructive Testing annual meeting in March, 1993. These results led to Langley Research Center filing a patent application in May titled "A quality monitor and monitoring technique employing optically stimulated electron emission."

Current plans call for the dual-use development of OSEE for both NCMS and NASA applications. NASA and NCMS signed a Space Act Agreement on March 10, 1994. The Agreement calls for NCMS to provide NASA $40,000 for research and development. Because this proposal was the first of its kind between NCMS and NASA, it has required significant legal review. A major point of negotiation has involved rights to intellectual property developed during the NCMS-funded investigation.

Under the reimbursible Space Act Agreement, Langley is using the OSEE technique to inspect a test matrix of three substrates each contaminated by three contaminants. They have completed 8 of the 9 tests and are awaiting receipt of the final test coupon from AT&T. The OSEE technique was able to identify the contaminants in 7 of the 8 tests completed to date. Dr. Welch is preparing a final report to be issued upon completion of testing of the last specimen.

Dr. Welch has presented the OSEE inspection technique at two conferences:
The International Conference of Solders, Fluxes, and Pastes
Atlanta, GA, June 1994
Surface Mount International
San Jose, CA, Sept. 1994

The November 1994 issue of *NCMS Focus* contained a two page article on the project. Dr. Welch and Dr. Yost are awaiting final notification that their patent application has been awarded.

PROJECT TITLE: **Medical, Electrolytic Oxygen Concentrator**

SOURCE OF OPPORTUNITY: **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.

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 signed by both parties. The agreement calls for a Healthdyne investment of $200K in the project. Phase IIa of the project was initiated with a milestone review set for May 2, 1994. RTI participated in an in-process review at Healthdyne; Healthdyne agreed to fund Phase IIb. Phase IIb has been completed with partial success and a proposal for Phase III start-up submitted to Healthdyne. If Healthdyne commits to Phase III, NASA will cost-share in the amount of $50K.

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

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

RTI Team 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 vary according to the type of microorganisms supported by the particular food.

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 destructively testing the package. 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.

NASA Technologies

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. 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 1993. It was subsequently sent to other federal laboratories via the Federal Laboratory Consortium, in accordance with the NASA/FLC agreement. Twelve responses were received from 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 final candidate technologies were all proposed by DoE. For this reason RTI arranged to meet with NFPA and DoE at DoE Headquarters in Washington, DC. The October 27, 1993 meeting was a video-conference with researchers from Idaho National Engineering Lab and Savannah River Lab linked in remotely. The outcome of the meeting was a formal hand-off of the NASA-developed opportunity to DoE. As a result of this effort, Greg Reck received formal thanks from Roger Lewis, DoE Director of Technology Utilization.

The DoE technologies were presented to the NFPA membership at a conference on plastic package integrity testing in May, 1994. The NFPA reported to RTI in November, 1994 that testing with the DoE technologies was underway.

PROJECT TITLE: **Residence Time of Food Particles in Stainless Steel Pipes**

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

RTI Team Personnel: Molly O'Donovan Dix

Background

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.

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 sterilization 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 way 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. Solutions to the problem must be:

- noninvasive such that it does not impede food product flow
- capable of measuring individual particle velocities
- functional with food in two phase flow (particles in opaque solution)
- function with food in 316 stainless steel pipe

TESTING PARAMETERS

	TYPICAL	MAXIMUM
Pressure (psig)	60	100+
Temperature (°F)	270-285	300+
Flow Velocity (m/s)	0.1	1
Pipe Diameter (in.)	1.5	2
Pipe Wall Thickness (in.)	0.065"	—
Pipe Length (in.)	>100"	—
Particle Density (g/ml)	1 to 1.2	—
pH	4.6	—
Particle Size	0.25"	—
Mix Ratio	5-80% particles/liquid	

NASA Technology

The problem statement generated 29 responses from four agencies. The responses from NASA were as follows: MSFC, 2; SSC, 1; LaRC, 3; JSC, 1; KSC, 3.

Participants

Dr. Jeff Barach, V.P.Eastern Research Laboratory, National Food Processors Association.
Dr. Dilip Chandarama, National Food Processors Association

Status

Two NASA technologies and 1 Naval proposal were identified as promising. The NASA technologies are from MSFC and JSC. RTI arranged a series of conference calls with NFPA and the researchers to quantify the resources required to reach proof-of-concept. Technology

summaries and development cost estimates were presented to appropriate NFPA member companies at a meeting on April 6, 1994. The aseptic process is currently under review by the Food & Drug Administration. If the process is approved the NFPA and member companies will move forward with specific projects.

PROJECT TITLE: **Simpson Probe: Self-Nulling Eddy-Current Flaw Detection Device**

SOURCE OF OPPORTUNITY: **Langley Research Center**

RTI Team Personnel: Molly O'Donovan Dix

Background

In an effort to enhance the Airworthiness of America's Aging Commercial Airline fleet NASA Langley Research Center (LaRC) has investigated ways to advance conventional eddy-current techniques used to detect structural flaws. Research in this area has resulted in the development of the Self-Nulling Eddy-Current Probe, which has been shown to be extremely sensitive to fatigue cracks in Aluminum alloy plates. Large areas can quickly be inspected and unambiguous flaw indications are displayed.

Eddy-current methods require no couplant to be applied to the material under test and have been shown to be effective for fatigue inspection. An impedance bridge and null circuitry are conventionally used to detect changes in the impedance of a coil as it passes over a test part. Impedance changes can be very small, so high gain amplifiers are often employed to observe the effects of flaws. Signals are often monitored on a complex impedance plane, and interpretation errors are not uncommon.

NASA Technology

The Self-Nulling Eddy-Current Device developed for the inspection of surface flaws on conducting materials provides the operator with a clear, unambiguous flaw indication without the need for prior calibration, balance circuitry, or reference standards. A unique driver-pickup coil configuration produces a zero output voltage when unflawed material is inspected. In the presence of a fatigue crack a large output voltage is recorded. Studies have shown flaw responses to be extremely stable and repeatable while lift-off errors are negligible. Prototype units have been constructed using nine volt batteries as a power source and having a total weight of less than 1/2 pound.

The unique operating characteristics of the Device enable test parts to be rapidly scanned, monitoring only the amplitude of the pick-up coil signal. Flaw sizing cart be determined by the amplitude of the signal, with fatigue cracks of lengths comparable to the probe dimensions producing a signal amplitude of the order of the in-air signal. No calibration standards are required, only very simple instrumentation is needed, signal interpretation is trivial, inspection times are short, and high sensitivity is achievable.

Participants

- Dr. Min Namkung, NASA Langley Research Center
- B. Wincheski, NASA Langley Research Center
- John Simpson, NASA Langley Research Center
- Dr. Jim Fulton, NASA Langley Research Center
- Dave Jankowski, Krautkramer Branson, Lewistown, Pennsylvania

Status

RTI performed a technology assessment, identified appropriate companies to contact (some company names were provided by the LaRC NDT group, for these RTI validated their value as potential commercialization partners), assisted in developing a Technical Briefing Brochure (edited text, completed layout), invited the target companies, followed-up with priority target companies, attended the technical briefing, followed-up with interested companies and acted as preliminary interface with Krautkramer Branson.

Krautkramer Branson was selected as Langley's Commercialization Partner based on an excellent Commercialization Plan submitted early in 1994. A license agreement was successfully negotiated and commercialization of the technology is in process.

PROJECT TITLE: **Smart Sensing Technology Predictive Response Method**

SOURCE OF OPPORTUNITY: **Stennis Space Center (SSC)**

RTI Team Personnel: Molly O'Donovan Dix

Background

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
- Katherine J. Nichols, IVAC Corporation

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 agreed 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 Announcements 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 their electronic thermometer. Conversations have been in process with IVAC since October 1992. In March 1993, 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

RTI assisted in the development and review of a draft Space Act Agreement between NASA and IVAC which was signed at the end of 1993. (IVAC has requested no publicity until after the product has reached the commercial market.) The cooperative project between SSC and IVAC was successfully completed in 1994. IVAC will include the SSC technology in future models of electronic thermometers. The technology may provide IVAC thermometers with a response time of 9 seconds, a significant improvement.

NOTE: IVAC has requested that NASA not publicize this project until the product has reached the commercial market.

PROJECT TITLE: **Ultrasound Displacement Amplitude Measurement**

SOURCE OF OPPORTUNITY: **Langley Research Center**

RTI Team 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 respectively.

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 described the technology and the commercialization opportunity. This opportunity sheet was sent to over 40 companies targeted as potential commercial partners. Six companies originally expressed interest in the technology.

A technology briefing was held on October 21, 1993 in conjunction with the Langley Technology Opportunity Showcase (TOPS). One company attended the briefing and three others requested additional information (including a videotape of the briefing). Follow-up packages were sent to all four companies on November 17, 1993. Both positive and negative responses were requested by the end of January.

None of the companies that originally expressed interest have requested commercialization of the technique. Commercial feedback indicates that until a major study is completed that proves medical danger resulting from ultrasound, there is no market for calibration.

PROJECT TITLE: **Using Sensors to Continuously Measure Crop Yield**

SOURCE OF OPPORTUNITY: **Equipment Manufacturers Institute in association with the U.S. Department of Agriculture**

RTI Team Personnel: Molly O'Donovan Dix

Background

Crop harvest and the yield data from it enable the farmer to determine whether or not the production process has achieved the desired goals for the season. Knowing yield data for a specific location in a field will allow farmers to modify their strategies for future chemical applications, seed population, and field preparation.

Farmers that have survived today's competitiveness in the world marketplace have become better business people. They want to know more about their ongoing production process and are no longer willing to settle for information after the harvest or on an average basis. Farmers want to know with "precision" the important parameters associated with their operation.

Recently, the concept of "precision" or "prescription" farming has emerged as a means of better understanding the elements associated with the farming process: field preparation, chemical composition of the soil, and the yield achieved at a given location. Navigational aids, such as Global Positioning Satellites (GPS), identify the specific location of the vehicle, which is recording data. The data are placed on field maps that are maintained on computer storage media for future updates and comparisons.

A cost-effective means of measuring moisture, temperature, and weight (volume) of crops is needed to determine yields in the field during the harvesting process. In today's agriculture, technologies exist for taking such measurements under stationary conditions, but they have not been implemented successfully "on-the-go."

State-of-the-Art

In stationary applications, the current technology for determining *moisture* level is measuring the dielectric properties of the grain and calibrating this value to actual moisture by a "hot air oven" method. The grain is placed in a test cell where temperatures are measured. The sides of the

test cell make up the plates of a capacitor. The capacitor value is then calibrated to a known moisture value.

Another stationery method utilized today employs Near Infrared (NIR) optical technology to determine the moisture content of a prepared sample. By measuring the spectral level of the different frequencies of light reflected off of the prepared sample, the moisture content of the sample can be determined through calibration methods to know samples. These methods are costly and not very conducive to mobile vehicle applications.

The three methods used for measuring *temperature* include: Resistor Temperature Detectors (RTDs), Thermo-Couples, and Thermistors. These are all suitable approaches used today in mobile applications.

The methods for measuring *weight* include strain gauge load cells and hydraulic load cells, both of which are suitable and used today n mobile applications. The volume of grain versus time can also be of interest for this applications. A method used today is placing a strain gauge sensing device in the clean grain auger flow path; the force on the sensor is calibrated to the flow volume, thereby giving an indication of the volume of product flowing into the grain truck.

Technology Specifications

These sensors will be applied to machines that harvest a wide variety of grains and seeds, such as corn, soybeans, wheat, and sunflowers; and forage crops such as hay and straw. *It is desirable that the same sensor be used for all applications.* Accuracies must meet the following requirements:

Yield (bu/acre)	1 percent accuracy
Average Yield (bu/acre)	1 percent accuracy
Total Yield (bu/acre)	3 percent accuracy
Acres harvested	2 percent accuracy
Percent moisture	0.5 percent accuracy
Average moisture	0.5 percent accuracy

The range of measurement must account for:

Moisture levels from 0 to 50 percent
Weight measurements up to 2,000 lbs.
Temperature from -20°C to +85°C

The equipment these sensors will be applied to operates between +9.8 and + VDC. In many cases, these sensors will be used in conjunction with controllers or monitors which can supply either +8VDC or +5VDC regulated sensor outputs.

NASA Technology

Proposals were received from NASA researchers and forwarded to the Equipment Manufacturers Institute (EMI) as follows:

- Infrared and Microwave Technology
  NASA Jet Propulsion Laboratory: Dr. J. David Nichols

- Synthetic Aperture Radar
  NASA Jet Propulsion Laboratory: Dr. J. David Nichols

Status

The NASA proposals were forwarded to the Equipment Manufacturers Institute between November 1993 and January 1994 as they were received. The EMI reviewed the responses and did not select this problem for further research. EMI member companies have been encouraged to contact directly researchers with proposals of interest.

PROJECT TITLE: **Using Sensors to Determine Soil Property Data**

SOURCE OF OPPORTUNITY: **Equipment Manufacturers Institute in association with the U.S. Department of Agriculture**

RTI Team Personnel: Molly O'Donovan Dix

Background

As the cost and the ecological impact of farm fertilizer and chemicals continue to rise, the concept of "precision" or "prescription" farming is becoming increasingly attractive.

Precision farming recognizes that there are differences in soil type and chemical concentrations within a given crop field. These variabilities are mapped, and application rates of chemicals and seed are varied across the field in accordance with a strategy designed to maximize the farmer's return on investment.

Sensors that can be mounted on an implement, pulled through a field are needed to output real time soil property data in order to control the application of fertilizers and other materials "on the go," or to generate a soil map. Depending on the technology utilized, the sensor might "look" at the soil surface or actually penetrate the soil surface by 1-2 inches.

State-of-the-Art

Currently, the soil data are generated by typically laying out a 300 ft. by 300 ft. grid over a field and physically taking soil samples. The samples are analyzed in a lab; the chemical/fertilizer requirements for each portion of the field are determined; and a field map is created. This "prescription" is then loaded into a computer which, coupled with a navigation aid such as Global Positioning Satellite (GPS), controls the application rates to meet prescription requirements.

To close the loop, yield data from the harvest, again on each portion of the field, also are stored in the field map and used to confirm or correct the strategy to be used in the following season.

Technology Specifications

Sensors should be capable of determining fertility by sensing:

a. Nitrates (NO_3) 5-100 ppm
b. Phosphorous (P_2O_5) 2-50 ppm
c. Potassium (K_2) 25-200 ppm
d. pH (4.5-8)
e. Moisture
f. Organic matter (0 to 6 percent)

Operating temperatures are in the range of 0 to 70°C, with storage temperatures between -40°C to +85°C. Typical travel speeds across the field range from 3 to 7 mph. Cost in the range of $50 to $100 per sensor are desired.

NASA Technology

Proposals were received from NASA researchers and forwarded to the Equipment Manufacturers Institute (EMI) as follows:

- Heat Driven Technology
  NASA Marshall: W.T. Powers

- Ion Selective Electrodes
  NASA Ames: Lynn Kim

- Site Specific Crop Management
  NASA Langley: Vernon P. Gillespie

Status

The NASA proposals were forwarded to the Equipment Manufacturers Institute between November 1993 and January 1994 as they were received. The EMI reviewed these responses. This problem was not selected for further research. EMI member companies have been encouraged to directly contact researchers with proposals of interest.

PROJECT TITLE: **Using Sensors to Measure and Control the Applications Rates of Liquid and Granular Agricultural Materials**

SOURCE OF OPPORTUNITY: **Equipment Manufacturers Institute in association with the U.S. Department of Agriculture**

RTI Team Personnel: Molly O'Donovan Dix

Background

There are two classes of materials to be sensed: liquids--fertilizer, herbicide, and insecticide; and granular materials--fertilizer, herbicide, insecticide, and small seeds. All the liquids can be applied by the same metering devices and all of the granular materials are applied with similar metering devices. It is common to apply pesticides and fertilizer simultaneously from different meters on the same machine when planting row crops.

Accurate metering and measurement of the application rates of liquid and granular materials has a significant economic impact on the success of an agricultural enterprise. This is due to the high cost of these materials and the effect of improper application on crop yield. Excessive application of many of these materials also has a negative effect on the environment. This has led to legislated requirements to record applications rates, and may lead to further requirements to more accurately control these application rates.

State-of-the-Art

Many application systems for liquids and granular materials use open loop meters that apply at fixed or constant rates under constant conditions.

Liquid materials. Liquid applicators may rely on constant displacement pumps that are driven at fixed speeds, or on constant pressure pumps that deliver material through a fixed orifice or multiple nozzles. The application rates of these systems deviate from the set rate when operating parameters change. Application rates are sensitive to a number of parameters such as vehicle speed, pump drive speed, system pressure, and nozzle or orifice wear, etc. Existing technology to measure high rates of liquid flow are not applicable to the low flow rates (2-200 ounces/minute) required to monitor injection spray systems, and existing individual nozzle flows (.05-8 gallons/minute) of other spray systems.

Granular materials. Granular flow meters experience similar unsensed and uncorrected variation in application rates caused by changing conditions. No practical sensor technology for measuring granular flow rates in mobile equipment is available at the present time.

Technology Specifications

A. Performance. Liquid flow sensors must measure with an accuracy of better than 5 percent (2 percent desired) of full flow range. The flow range is 2-200 ounces/minutes for injection spray systems; .05-10 gallons/minute for individual spray nozzles. Granular flow sensors must measure with an accuracy of better than 5 percent (2 percent desired) of full flow range.

B. Environment. The sensor must meet ANSI/ASAE Standard EP455 (see attached) including electromagnetic compatibility (EMC) and electromagnetic interference (EMI) standards. Operating temperatures will range from 0 to 70°C, and storage temperatures from -40 to 85°C.

C. Reliability. The sensor must have a minimum b_{10} life of 1000 hours at the 70 percent confidence level.

D. Cost Constraints. Unit cost should not exceed $15.00 each. Estimated sales volume is on the order of 100,000 units annually.

NASA Technology

Proposals were received from NASA researchers and forwarded to the Equipment Manufacturers Institute (EMI) as follows:

- Thermal Mass Meters
  NASA Marshall: W.T. Powers
- Ultrasonic Flow Meters
  NASA Marshall: W.T. Powers
- Charge Coupled Device (CCD) Imager
  NASA Jet Propulsion Laboratory: Philip I. Moynihan
- Metering Chamber
  NASA Marshall: W.T. Powers

Status

The NASA proposals were forwarded to the Equipment Manufacturers Institute between November 1993 and January 1994 as they were received. The EMI reviewed these responses and did not select this problem for further research. EMI member companies have been encouraged to contact directly researchers with proposals of interest

PROJECT TITLE: **Using Sensors on Agricultural Equipment to Reduce Human Risks**

SOURCE OF OPPORTUNITY: **Equipment Manufacturers Institute in Association with the U.S. Department of Agriculture**

RTI Team Personnel: Molly O'Donovan Dix

Background

A sensor-based system is needed that will detect, warn and/or compensate for the presence of operators and other people when they are in close proximity to operating agricultural machinery where a potentially hazardous condition exists. The use of any such system should be limited to situations which, if not avoided, will result in serious injury or death.

Entanglement in or contact with moving elements of agricultural machinery continues to be a mode of farm accidents that frequently results in serious injury or death. Currently used safety strategies such as passive barriers, safety signs and messages, and operator education/training have been shown to be only partially effective in alleviating this situation.

Surveys have revealed that it is not unusual for farmers to remove the protective shields and guards over moving machinery parts for servicing or for adapting equipment for different uses, without replacing them. Moreover, there is a variety of equipment, such as soil working tools, and crop cutting/gathering mechanisms where the presence of a guard would render the machine nonfunctional.

State-of-the-Art

Passive Barriers, Safety Signs and Messages, Education/Training. These are some methods currently used to enhance safety. However they have been shown to be only partially effective in alleviating the situation.

Interlock Systems. Interlock systems are used in a few agricultural equipment applications such as for preventing the engine from starting unless the transmission is in a neutral position (ref: ASAE Standard S318; SAE Standard J208); stopping the moving parts of forage wagons; operator restraint systems for skid steer loaders (ref: SAE Standard J1388); and shutting off some moving parts of cotton pickers when the operator leaves the seat. See attached ASAE paper 88-

5516, "Human Presence Activated Safety Systems for Mobile Off-Road Equipment", for a general discussion of "state-of-the-art."

Radar, Infrared and Ultrasonic Sensor Technologies. Research conducted by the industry in the 1980's indicated that commercially available radar, infrared and ultrasonic sensor technologies did not perform satisfactorily for agricultural and industrial equipment applications.

Technology Specifications

Sensor systems sense the presence of any person, including a child, when the equipment operator is not at the designated operator's stations; and/or when any person is in the proximity of the hazard. The size and locations of the sensor(s) must not interfere with normal operation of the equipment, i.e., the system must provide "transparency" (unobtrusiveness) when recommended procedures for machine operations or servicing are followed. Response time must not be more than a few milliseconds.

Environmental requirements must meet ANSI/ASAE Standard EP455. Sensor must operate in the temperature range of +70°C to -30°C. Storage temperatures must be between +85°C and -40°C. Sensors must have a minimum b_{10} life of 7000 hrs. at the 70 percent confidence level.

The cost of the whole system, not of the sensor(s) alone, is the dominant factor. The cost of the system may be acceptable to the end purchaser if the system can be integrated with readily valued (and value-added) features/capabilities. Customer acceptance of incremental cost increases is usually related to the price of the whole product package which, for agricultural equipment, ranges from under $5000 to as much as $200,000.

Estimated initial sales volumes in the agricultural equipment industry are 10,000 - 100,000 units annually (U.S. only), depending on the number of applications for which a system is shown to meet the criteria specified herein. A successful system could potentially be adapted for use in the construction, mining, forestry, materials handling, transportation and manufacturing industries.

NASA Technology

One proposal from NASA Johnson indicated to the Equipment Manufacturers Institute members NASA's interest in addressing human interaction with automated equipment for crop production and processing. NASA's interests relate to the requirements for closed environment crop management for extended space flight. Areas of specific dual-use potential include machine vision, proximity detection, and collision avoidance for robotics.

NASA would welcome proposals for cooperative development of technologies to address these needs.

Status

The NASA proposals were forwarded to the Equipment Manufacturers Institute between November 1993 and January 1994 as they were received. The EMI/USDA team selected two projects to fund more detailed research into potential and proposed solutions. This problem was one that was selected because a solution is easily shared throughout the industry. The original problem statement will be revised and all NASA centers will be invited to respond. The Johnson researcher will be contacted and asked to update previously submitted information. A report with all proposals will be published and sent to the appropriate agricultural equipment manufacturers. Companies will be encouraged to contact researchers with technologies of interest.

Action

RTI will interface with all of the Centers for distribution and response to the revised problem statement. The statement is due out in January with an August response deadline.

PROJECT TITLE: **Using Sensors to Detect Potentially Hazardous Atmospheres in Production Agriculture**

SOURCE OF OPPORTUNITY: **Equipment Manufacturers Institute in Association with the U.S. Department of Agriculture**

RTI Team Personnel: Molly O'Donovan Dix

Background

Agricultural workers are exposed to certain biogenic gases produced in "confined spaces" including, but not limited to liquid manure retention pits and silos. Workers also are exposed to a variety of chemicals used as pesticides, herbicides and fertilizers in the form of vapors, aerosols or particulate matter. Agricultural chemicals can reach hazardous concentrations in storage and mixing areas, open fields and orchards (during or after application), and in the enclosed cabs of tractors and other machinery.

The more serious atmospheric hazards found in production agriculture are manure gases, silo gases, and agricultural chemicals:

Manure Gases. Liquid manure storage systems have come into prominent use in recent years. Many dairy, beef and hog operations (and to a limited extent poultry operations) now use liquid manure systems as a fast and economical method of handling animal wastes. These systems, particularly if they are incorporated into enclosed livestock housing facilities, may pose a serious hazard because of the gases they produce (see attached, ASAE EP470). Decomposing animal manure gives off a variety of gases including hydrogen sulfide, carbon dioxide, ammonia, and methane. The accumulation of these gases within the confined space of the manure pit can produce an oxygen-deficient, toxic, and/or explosive environment. Of these gases, hydrogen sulfide and ammonia are the most toxic.

Silo gases. Silage fermentation may produce several kinds of gas, including carbon dioxide, oxides of nitrogen (NO, NO_2, and N_2O_5) and sulfur dioxide. Farmers must occasionally enter tower silos at or near the top, above the stored silage, to manage the process of removing portions of the silage for the feeding of animals, or to service equipment. Because nitrogen dioxide is heavier than air, it remains beneath the air mass, hovering over the silage. The gas can form a layer on top of the silage below the upper edge of the top door, or it settles down through the chute. Nitrogen dioxide also may seep through the drain at the base of the silo. It often concentrates in the silo room and moves into the barn, posing a threat to both animals and workers.

Agriculture Chemicals. People who work with or near herbicides, pesticides, fungicides or fertilizers may be at risk for both acute and chronic health hazards. Acute pesticide poisoning accounts for an estimated 20,000 emergency room visits each year, and approximately 10 percent of these cases are admitted to the hospital. Currently, approximately 600 active pesticide ingredients are used. Typical chemical families include triazines, dinitroanalines, phenoxyls, thiocarbamates, acetylanalides, organophosphates, and pyrethrums. Agricultural chemicals may be present in an atmosphere as a vapor, aerosol, or particulate.

Lower cost, faster responding sensors that detect more chemicals are needed for separate systems to (a) continuously monitor or (b) rapidly detect the presence of atmospheres that are potentially hazardous to people or farm animals, and to warn against and/or compensate for them. There are generally three kinds of hazardous atmospheres in production agriculture:

- Oxygen Deficient
- Toxic
- Flammable or explosive

Systems that *continuously monitor* atmospheres could be stationary, portable, or installed in a farm vehicle such as a tractor. Systems that *rapidly detect* potentially hazardous atmospheres would be carried or worn by a person.

Technology Specifications

Sensitivity. The sensor should respond to the presence of the hazardous chemical at a level below that deemed to present a long-term hazard. The sensor should be insensitive to the presence of non-hazardous materials.

Response Time. For systems that monitor continuously, the sensor should respond within 30 seconds of reaching the level that exceeds the allowable long term exposure level.

Reliability. The sensor must have a minimum b_{10} life of 7,000 hours at the 70 percent confidence level.

Environmental. The sensor must meet ANSI/ASAI Standard EP455 (see attached) including electromagnetic compatibility (EMC) and electromagnetic interference (EMI) testing. Operating temperatures will range from 0°C to +70°C, and storage temperatures will range from -40°C to 85°C. Relative humidity reaches 100 percent.

Cost. Unit cost should not exceed $100 (sensor only) for a single, wide range sensor. If the system requires a specific sensor for a particular chemical, unit cost should not exceed $25.00. Estimated initial volumes for continuous monitoring type sensors are 5,000 - 20,000 units annually (U.S., production agriculture only). Annual volumes for rapid-detection sensors could run in the hundreds of thousands depending on the cost.

NASA Technology

Proposals were received from NASA researchers and forwarded to the Equipment Manufacturers Institute (EMI) as follows:

- Miniature Gas Chromatography Systems (Mini-GC)
  NASA Ames: Lynn Kim
- Trace Atmospheric Carbon Monoxide Sensor
  NASA Marshall: Martin Johnson
- Portable Hazardous Gas Detector (Electrochemical Sensors)
  NASA Johnson: Daniel Barta
- Smoke Detector for Areas with Atmospheric Particulates
  NASA Johnson: Daniel Barta
- Tandem Mass Spectrometer
  NASA Marshall: Martin Johnson
- Micro-Electrical Sensors
  NASA Ames: Lynn Kim
- Ion Mobility Sensors
  NASA Johnson: John James
- Ammonia Sensitive Coating
  Southwest Research Institute in conjunction with NASA Johnson

Status

The NASA proposals were forwarded to the Equipment Manufacturers Institute between November 1993 and January 1994 as they were received. The EMI is still reviewing these responses.

Action

Continue to follow-up with the EMI to maintain contact with the status of the NASA technology suggestions.

TASK STATUS

NASW-4367. The following

7.0 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
- TASK 7: Technology Transfer and Commercialization Assistance to the Kennedy Space Center

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 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: Steve Monteith
Start Date: November 1991
Completion: December 1994

Background

NASA Headquarters requested that RTI develop two prototype database systems:

- Spinoff Technology Application Retrieval System (STARS), a multimedia system for storage and retrieval of NASA Technology Spinoff information.

- Technology Tracking System (TechTracS), a system for Field Center management of NASA new technology reports, patent applications and patent licenses.

Objectives

The purpose of this task is to support NASA Headquarters 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 worked with NASA Headquarters to specify the requirements for the STARS system, both hardware and software. RTI generated various prototype designs for review by NASA and assisted NASA in determining the best configuration of hardware and software for the system. STARS was completed and delivered to NASA.

RTI has completed STARS development activities funded under this add-on task including the benefits analysis being performed by Chapman Research Group. Hardware and software systems 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 a VCR and/or laserdisc players. The system has been delivered to NASA Headquarters with user manuals and documentation for the process of updating STARS.

Additional funding was provided for maintenance support of the installed base of the STARS application and to improve performance and functionality as specified by NASA HQ. Areas addressed included: congressional districts, keywords, 1992 Spinoffs, and software updates.

STARS has received widespread exposure at various national and regional meetings and has been installed at various locations for both NASA and public use. STARS was recently used in a NASA demonstration in the Congress' Rayburn building and in an exhibit at the California State Fair.

Technology Tracking System (TechTracS)

Background

NASA Headquarters initiated a request for RTI to enhance and distribute a technology database initially developed for NASA Kennedy Space Center. The primary use of the database is for tracking new technology being generated by research from NASA employees and government contractors. The name for this system has been designated as the Technology Tracking System (TechTracS).

Objectives

The purpose of this task is to support NASA Headquarters in meeting the following objectives: 1) Deploying an information system that is capable of tracking new technology from the point of being reported to the point of being licensed, 2) providing NASA Field Center personnel with a productivity tool that can generate correspondence between inventors and contractors. In this effort, RTI worked with NASA Headquarters and appropriate Field Centers to specify requirements for TechTracS.

Status

TechTracS has been installed at all NASA Field Center Patent Offices with the required hardware systems. RTI has completed the following TechTracS development activities in the last quarter of the reporting period:

1) Training was held on October 24 through 27, 1994 during which users from all NASA field centers were trained on the use of TechTracS.
2) Installation of TechTracS and the merge of data from HQ at Ames Research Center.
3) Data mapping, pre-installation and installation of TechTracS at JSC Patent and Technology Utilization Office.
4) Provided user-level documentation.
5) Pre-installation of TechTracS at NASA Headquarters.

Software code for TechTracS was delivered to John Yin, NASA Ames Research Center, in December 1994.

In a possible extension of the contract, installation and addition training will be provided for the remaining NASA Field Centers and NASA Headquarters.

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: December 1994

Background

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 assistance to NASA HQ's Program planning and analysis of the National Technology Transfer Center activities in the reporting period has been for the development of the Technology Commercialization Learning Tool software application.

Technology Commercialization Learning Tool

The Technology Commercialization Learning Tool application runs in the PC Windows environment. It has been developed, under the direction of NASA Code XC and the National Technology Transfer Center (NTTC), by Research Triangle Institute (RTI). The application has been designed to allow the authoring of **custom** question/answer-based Learning Tools.

The focus subject of the development of this application has been to aid users in learning basic Technology Commercialization concepts. However, the application itself does not limit the user to any particular subject.

There are two basic components of the application:

- **The Learning Tool Designer** - The Designer (or Authoring Tool) allows the user to define and create the actual questions as well as create the desired combination of questions of which the Learning Tool will be comprised.

- **The Learning Tool** - The Learning Tool itself is a custom, stand-alone application which can be run by anyone to aid in the learning of a desired subject. The Learning Tool is a distribution-free application and will fit onto a single computer diskette for easy distribution.

The basic Technology Commercialization Learning Tool has been completed. A possible extension of the task will enable refinement of the software to be compatible with the question content currently being developed by another contractor.

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: July 1994

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 reporting period.

Technology 2003

- Coordinated the Technology 2003 symposia including selection of moderators, layout and set-up of NASA exhibit, and general on-site support.
- Completed work and delivered camera-ready copy to NASA Printing and Graphics for the Conference Proceedings.
- Began work to put Technology 2003 Conference Proceedings on-line as well as those of future shows.
- In the process of developing a post-conference report for NASA HQ on the effectiveness of these conferences based on survey results from the TU Foundation and specific cases of partnerships resulting from these shows.
- Developed and distributed the Call for Papers for Technology 2004. This included direct mailing to all FLC member contacts, plus ads in Commerce Business Daily and the FLC Network. Direct mailing to NASA Center Directors still has yet to be signed off by NASA Code C Acting Associate Administrator.

One hundred slides with supplemental information were delivered to NASA Headquarters. The slides addressed the technology transfer network and process as well as successful spinoffs.

8.0 TRAVEL

September 29-October 1, 1993: RTI traveled to NASA Langley Research Center for a TechTracS Review.

October 3-6, 1993: Dan Winfield traveled to Charleston, SC to give a presentation on Federal technology transfer to the 47th National Conference on the Advancement of Research.

October 7-8, 1993: Stephen Lehrman represented the NASA Technology Transfer Program at the American Society of Mechanical Engineers Technology Opportunities Planning Committee meeting in Washington, DC. Mr. Lehrman recommended that ASME contact Dr. Chris Chamis (Lewis) regarding computer software for composite structure design and Chris Culbert (Johnson) regarding a decision support system for the management of safety and availability of power boilers.

October 19-21, 1993: Gary Hughes, Molly Dix and Dan Winfield attended the Langley Research Center Technology Opportunities Showcase, Hampton, Virginia. A number of technologies were reviewed and researchers interviewed for commercialization potential.

October 20-23, 1993: Molly O'Donovan Dix assisted in the planning and implementation of two technology briefings held in conjunction with TOPS. A briefing on Langley's Ultrasonic Amplitude Displacement Measurement Techniques was held on October 21. The second briefing was for the Simpson Probe -- Self-Nulling Eddy-Current Flaw Detection, this was held on October 22.

October 25, 1993: Stephen Lehrman presented the NASA Technology Transfer Program to Hoechst-Celanese Corp. in Charlotte, NC.

October 27, 1993: Dan Winfield traveled to NASA Headquarters to review projects with Ray Gilbert.

October 27, 1993: Molly O'Donovan Dix and Daniel Winfield traveled to Washington, DC to meet with the National Food Processors Association (NFPA) and the Department of Energy (DOE). RTI had developed a relationship with the NFPA developed and distributed a problem statement and assessed proposed solutions from several agencies. Three of the technologies of interest were from DOE. RTI arranged the DC meeting to hand off the transfer opportunity from NASA to DOE.

November 3-5, 1993: Gary Hughes attended training at the Langley Research Center for evaluating new technologies.

November 4-5, 1993: Doris Rouse met with Len Ault to discuss Application Team plans.

November 8, 1993: Gary Hughes traveled to Washington, DC for the American Society of Mechanical Engineers special meeting of parties interested in forming a consortium to address continuous monitoring of stack emissions from industrial incineration processes. RTI's interest is in the potential for developing a problem statement with this group.

November 10, 1993: Doris Rouse with Len Ault and Frank Penaranda at NASA HQ to discuss Application Team activities.

November 15-18, 1993: RTI traveled to NASA Kennedy Space Center for a TechTracS update.

November 16-18, 1993: Stephen Lehrman represented the NASA Technology Applications Team at the Federal Laboratory Consortium Fall meeting. Mr. Lehrman participated in the NASA Agency meeting.

December 1-3, 1993: Molly O'Donovan Dix traveled to Langley Research Center to attend a seminar on Market Opportunity Assessment presented by Ernest Cadotte of the University of Tennessee. Also while at Langley, Ms. Dix met with members of the Langley Technology Utilization office.

December 3, 1993: Stephen Lehrman represented the NASA Technology Transfer Program at the American Society of Mechanical Engineers National Laboratories Technology Transfer Committee meeting. The purpose of the meeting was to examine the purpose of this committee with expanded Federal Lab (e.g. NASA and EPA) and industry representation.

December 6-10, 1993: Dr. Rouse participated in the Technology 2003 conference in Anaheim, CA.

December 16-17, 1993: Doris Rouse and Steve Monteith met with Len Ault and Kevin Barquinero to discuss RTI's work on the TechTracS database.

January 11-12, 1994: RTI traveled to NASA Headquarters for meetings on TechTracS.

January 26-27, 1994: Gary Hughes attended the Comprehensive Technology Transfer Training Program in Los Angeles, CA. This program was sponsored by the Association of Federal Technology Transfer Executives and the International Society for Optical Engineering.

January 27-28, 1994: Gary Hughes traveled to Ames Research Center for a series of meetings with the Technology Commercialization and technical staffs (Artificial Intelligence Research Branch).

January 27-30, 1994: Dan Winfield attended the Virtual Reality Meets Medicine II Conference in San Diego and met with Paul Schenker, Jet Propulsion Laboratory, and Faina Shtern, National Cancer Institute, regarding a possible project in Image Guided Therapy.

February 1, 1994: Steve Monteith, Simon Wright, and Cindy Woloszyn demonstrated the TechTracS database to Langley Research Center's Technology Applications Group.

February 2-3, 1994: Doris Rouse made a presentation entitled "Industry Associations/Government Partnerships: A Model for Meeting Industry-Wide Technology Needs" at the Dual-Use Space Technology Transfer Conference and Exhibition at NASA's Johnson Space Center.

February 4, 1994: Gary Hughes participated in a Technology Briefing on the supersonic gas-liquid cleaning system at a location near the Kennedy Space Center. The technology was well received and several companies are preparing commercialization plans.

February 8, 1994: Dan Winfield traveled to NASA Headquarters to discuss new project opportunities with Mel Montemerlo, Code CD, David Lavery, Code CD, Ray Gilbert, Code CU, and Ron White, Code UL.

February 17, 1994: Molly O'Donovan Dix and two students from the Kenan-Flagler Business School at the University of North Carolina traveled to Langley Research Center to discuss commercialization opportunities relating to several polyimide materials developed at Langley. Stephen Lehrman participated in the meeting via tele-conference.

February 18, 1994: Doris Rouse met with Syed Shariq, Charles Redmond and Len Ault to discuss RTI's TechTracS database.

February 22, 1994: Doris Rouse met with Len Ault and Kevin Barquinero in Washington, DC to discuss the RTI Technology Applications Team activities.

February 24, 1994: Dan Winfield traveled to NASA HQ to conduct a meeting with General Electric concerning a possible dual-use medical imaging project with JPL.

February 28, 1994: Doris Rouse participated in a meeting of the Best Practices Subcommittee at NASA HQ.

March 9-11, 1994: RTI traveled to NASA Langley Research Center for TechTracS installation.

March 15, 1994: Dan Winfield traveled to NASA HQ for project discussions with Mike Battaglia, Code CU, Mike Weingarten, Code CU, and Don Stewart, Code UL.

March 15, 1994: Doris Rouse met with Mike Battaglia and Ty Taylor to discuss industry benefits of NASA technology that could be cited in response to an inquiry by the Congressional Joint Economic Committee.

March 23, 1994: Stephen Lehrman and Molly O'Donovan Dix attended the Workshop on Technology Transfer Opportunities for Business and Industry in Huntsville, Alabama sponsored by Marshall Space Flight Center, U.S. Army Missile Command, and U.S. Army Space Strategic Defense Command. Mr. Lehrman and Ms. Dix met with NASA MSFC researchers and discussed their technology and commercialization opportunities.

March 25, 1994: Stephen Lehrman and Molly O'Donovan Dix visited Marshall Space Flight Center to meet with Harry Watters in the Technology Utilization Office. RTI also met with MSFC researchers, Palmer Peters, and Jim Bilbro to discuss MSFC advances in Hall-Effect sensors and optics respectively.

March 28, 1994: Doris Rouse met with Mike Battaglia and Len Ault at NASA HQ to discuss Applications Team activities.

March 29, 1994: Stephen Lehrman and Gary Hughes met with Ray Gilbert and Mike Little of NASA HQ to discuss the Office of Aeronautics technology transfer interests.

April 11-13, 1994: Dan Winfield traveled to Kansas City to attend the Spring Meeting of the Federal Laboratory Consortium.

April 15, 1994: Gary Hughes traveled to Ames Research Center to assist with the Technology Briefing for the Scientists' Intelligent Graphical Modeling Assistant (SIGMA).

April 18, 1994: Dan Winfield traveled to Fairfax, VA to give a presentation on the NASA technology transfer program to the NASA Advanced Biomedical Technologies Workshop at Fairfax Hospital.

April 20-22, 1994: RTI traveled to NASA Goddard Space Flight Center for TechTracS installation.

April 21-22, 1994: Molly Dix and S. A. Lehrman presented the result of RTI's Commercialization Plan for NASA Langley's Colorless and Low Dielectric Polyimide Thin Film Technologies at Langley Research Center.

April 22, 1994: Gary Hughes traveled to Kennedy Space Center to assist with the Technology Briefing for the Particle Fallout Monitor.

April 22, 1994: Molly O'Donovan Dix, Stephen A. Lehrman and two MBA candidates from the UNC Kenan Flagler School of Business traveled to LaRC. The purpose of the trip was to present the RTI-developed commercialization plan for the LaRC colorless and low dielectric polyimides. As a result of the commercialization plan and related efforts, LaRC has executed two Space Act Agreements and three companies have expressed serious interest in licensing portions of the patent portfolio.

April 28, 1994: While in the San Francisco area on other business, Dan Winfield met with Bruce Webbon of NASA Ames to plan RTI assistance in assessing the market opportunity for negative pressure ventilation in respiratory care.

May 1-2, 1994: Dan Winfield traveled to Healthdyne Technologies, Inc. in Marietta, GA to participate in an in-process review on the medical oxygen concentrator project with Kennedy Space Center.

May 1-4: Doris Rouse participated in a NASA national technology transfer network meeting in Keystone, Colorado.

May 10, 1994: Doris Rouse and Steve Monteith traveled NASA HQ to discuss TechTracS with Jack Mannix, Curt Shoffner, and John Yin (NASA Ames).

May 10-12, 1994: RTI traveled to NASA Lewis Research Center for TechTracS installation.

May 18, 1994: Doris Rouse traveled to NASA Headquarters to discuss project activities.

May 24, 1994: Carlene Cearley and Doris Rouse met with Jonathan Root (NASA HQ) and Rob Riner (National Technology Transfer Center) at the RTI Washington offices to discuss the Technology Transfer Training Game software system under development by RTI.

May 27, 1994: S. A. Lehrman met with Dr. William Weber of OCG Microelectronic Materials Inc. in East Providence, RI. The purpose of the meeting was to discuss applications for the NASA Langley Research Center colorless and low dielectric polyimides.

June 14-17, 1994: RTI traveled to NASA Kennedy Space Center for TechTracS update.

June 15, 1994: Doris Rouse, Gary Hughes, and Dan Winfield traveled to Greenbelt, MD to discuss RTI projects with the Goddard Space Flight Center technology transfer staff.

June 19, 1994: Gary Hughes met with Karen Thompson and Peggy Evanich at Kennedy Space Center to plan for future dual use projects.

July 19-21, 1994: Doris Rouse traveled to Vandenberg Air Force Base, California to participate in the Technology Transfer Panel at the annual Spaceweek meeting. Dr. Rouse made a presentation on the development of partnerships between industry associations and NASA.

June 21, 1994: Molly O'Donovan Dix traveled to Washington, D.C. to attend the Law Enforcement Technology Conference. The focus of the conference was discussions on how to successfully transfer technology to the law enforcement community. The conclusion of the trip was that existing technologies are not adopted into this market because of financial restriction. For this reason it is not an industry for NASA to target for commercialization opportunities.

June 21, 1994: Dan Winfield traveled to Bethesda, MD to review proposals submitted under the NASA-NCI Technology Transfer to Digital Mammography Program.

June 22, 1994: Molly O'Donovan Dix participated in a meeting with Johnson Controls and the LaRC Technology Applications Group. Johnson Controls is interested in licensing a portion of the LaRC low dielectric polyimide patents for a specific application. Ms. Dix assisted in discussion of the technology and the licensing process. Johnson Controls is still evaluating the NASA materials for commercial application.

June 22-23, 1994: Doris Rouse participated in a meeting of representatives from NASA's Commercial Technology Network in Huntsville, AL.

June 23-24, 1994: Dan Winfield gave a presentation at the Technology Transfer Society Annual Meeting in Huntsville, AL on the NASA-National Cancer Institute Technology Transfer to Digital Mammography Program.

June 24, 1994: Doris Rouse made a presentation entitled "Industry Association/Government Partnerships: A Model for Meeting Industry-Wide Technology Needs." at the Technology Transfer Society Annual Meeting in Huntsville, AL.

June 28, 1994: At the request of Rosa Webster and Dr. Frank Farmer, RTI gave a formal presentation on RTI's technology transfer services, resources, and results to the Langley Technology Applications Group. The presentation made by Dr. Doris Rouse, C. Gary Hughes, and Molly O'Donovan Dix described RTI's methodologies by citing specific projects and results.

July 6-7, 1994: Doris Rouse met with Joe Heyman and members of the LaRC Technology Application Group to discuss RTI's process for researching the commercial potential of invention disclosures.

July 13, 1994: Doris Rouse made a presentation to the NASA LaRC Technology Council on a strawman process for RTI assistance in the assessment of LaRC invention disclosures.

July 21, 1994: S. A. Lehrman participated in a pre-licensing meeting for the colorless and low dielectric polyimides at NASA Langley Research Center. Mr. Pete Agostino of Chem Dev Inc. presented his license application to Dr. George Helfrich, Ms. Anne St. Clair, Mr. Greg Manual and Mr. Lehrman.

July 25-27, 1994: Dan Winfield traveled to Washington, DC to participate in the Health and Human Services Planning Meeting for an October Conference on Breast Imaging. Mr. Winfield gave a presentation on the NASA/National Cancer Institute initiative in technology transfer to digital mammography.

August 3-5, 1994: Dan Winfield traveled to San Francisco to participate in the Technology Transfer in Image Guided Therapy Workshop, sponsored by the National Cancer Institute and the Society of Cardiovascular and Interventional Radiologists. While in the Bay area, Mr. Winfield also met with Bruce Webbon and others at NASA Ames to discuss technology transfer support to Ames.

August 9, 1994: Gary Hughes attended the Industry/Laboratory Technology Transfer Committee Meeting at the National Institute of Standards and Technology, Gaithersburg MD.

August 23-25, 1994: RTI traveled to NASA Goddard Space Flight Center for TechTracS review.

September 13-14, 1994: RTI traveled to NASA Langley Research Center for TechTracS review.

September 15-16, 1994: Doris Rouse traveled to Marshall Space Flight Center in Huntsville, AL to meet with Benita Hayes and Harry Craft, Manager of the MSFC Technology Transfer Office. Dr. Rouse presented the results of RTI's study on key Alabama industries, employment trends and critical technology needs.

September 21-22, 1994: S. A. Lehrman attended the NASA Sensors Working Group meeting in New Carroltown, MD. The meeting, organized by Dr. Gordon Johnston of NASA HQ, is a forum for discussing NASA sensor and instrumentation programs and needs.

September 22, 1994: Dan Winfield traveled to Washington DC for technology transfer discussions with the NASA Sensors Working Group, Glenn Mucklow of Code ST and Frank Sulzman of Code UL.

September 27-29, 1994: RTI traveled to NASA Johnson Space Center for TechTracS installation.

October 11-12, 1994: Dan Winfield traveled to Washington, DC to attend the Capitol Hill Briefing on Novel Breast imaging Technologies. While in DC Mr. Winfield also met with various staff at NASA HQ concerning technology transfer initiatives.

November 1-2, 1994: Gary Hughes traveled to Langley Research Center. He assisted with a technology briefing (Commercial Opportunities Program) for the low temperature oxidation catalysts. He also met with Eric Madaras of the Nondestructive Evaluation Science Branch.

November 7-10, 1994: Several members of the RTI Technology Applications Team attended the Technology 2004 conference in Washington, DC.

November 11, 1994: Doris Rouse made a presentation to the Florida Medical Association meeting in Orlando entitled "Medical Benefits from NASA Technology".

November 21-22, 1994: Dan Winfield traveled to Pasadena, CA to serve on the Medical Advisory Board (MAB) for the Jet Propulsion Laboratory Robot Assisted Microsurgery (RAMS) project. The MAB provided feedback to JPL on the project objective and plans and on the prospects for commercialization.

December 7-8, 1994: Steve Monteith traveled to NASA Headquarters for a meeting with Jonathan Root and Doug Cannon on TechTracS.

December 7-8, 1994: Gary Hughes met with Kennedy Research Center Technology Transfer and technical staffs to review current dual use project candidates.

December 13-14, 1994: RTI traveled to NASA Marshall Space Flight Center for TechTracS installation.

December 15, 1994: S. A. Lehrman and Doris Rouse participated in a series of meetings at Goddard Space Flight Center. Mr. Lehrman met with:

Ms. Nona Minnifield and discussed the Applications Team planned assistance to GSFC during calendar year 1995;

Mr. Doug Leviton and discussed his work on rotary and linear optical encoders;

Dr. James Chern and discussed his work on new ultrasonic c-scan technology; and

Mr. Peter Monti and visited the new GSFC microelectronic and electro-optic fabrication facility.

December 21, 1994: Carlene Cearley and Doris Rouse traveled to NASA HQ to provide training on the Spinoff Technology Applications Retrieval System (STARS). Doris Rouse also met with Robert Norwood, Michael Weingarten and Len Ault to discuss RTI's activities in the development of NASA/industry partnerships.

APPENDIX A

NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF

APPENDIX A:
NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF

STAFF MEMBER	BACKGROUND	PROJECT RESPONSIBILITY
Doris J. Rouse, Ph.D.	B.A., Chemistry/Ph.D. Physiology. Seventeen 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.	B.S., Engineering Analysis/M.S., Biomedical Engineering. Ten years in NASA Technology Utilization Program. Eight years experience in product development and manufacturing in the medical device industry.	Coordination of biomedical and rehabilitation projects. Areas of specialization include ophthalmology and orthopedics. Provides technical direction for Team activities.
Stephen A. Lehrman, M.S.	B.S., Mechanical Engineering/M.S., Mechanical Engineering. Eight 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
Stephen D. Mangum, M.P.A.	B.S., Political Science/M.P.A., Master of Public Administration. Serving seventh 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.	Serves as Program Analyst. Areas of concentration include organizational management, budgeting and finance, and database management. Assists project managers in background, marketing/industry studies and development of cofunding opportunities. Also, assists in the preparation of marketing and outreach materials.
Dean H. Hering, M.S.	B.S., Electrical Engineering/M.S. Electrical and Computer Engineering. Four years serving NASA Technology Utilization Program. Over six years experience in electrical engineering, digital design, neural networks, and artificial intelligence.	Coordination of manufacturing and industrial projects. Areas of specialization include electrical engineering, digital design, virtual reality, and artificial intelligence.

APPENDIX A: NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF		
STAFF MEMBER	BACKGROUND	PROJECT RESPONSIBILITY
C. Gary Hughes, P.E.	B.S., Aeronautical and Astronautical Engineering / M.S., Aeronautical and Astronautical Engineering. Joined the NASA Technology Applications Team staff in 1992 after 25 years experience in industry. Broad experience base includes engineering and management in manufacturing, electric power plants, aerospace, consulting, market research and marketing.	Coordination of manufacturing and industrial projects. Areas of specialization include, mechanical and structural engineering, waste and environmental management, materials, and aeronautics.
Molly O'Donovan Dix	B.S., Mechanical Engineering 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.	Coordination of industrial projects and provides research support to other Team staff. Provides technical writing for Technology Opportunity Announcement and Spinoff! Sheets.

APPENDIX A: NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF		
STAFF MEMBER	BACKGROUND	PROJECT RESPONSIBILITY
Laura A. Schoppe, M.S.	B.S., Mechanical Engineering, M.S., Mechanical and Aerospace Engineering. Joined the Technology Applications Team in 1994 after 11 years experience in engineering, program management, and business development in the aerospace, defense and applied science industries.	Coordination of computing and communications projects. Areas of specialization include advanced sensors, signal processing, advanced computing, and image processing.

APPENDIX B

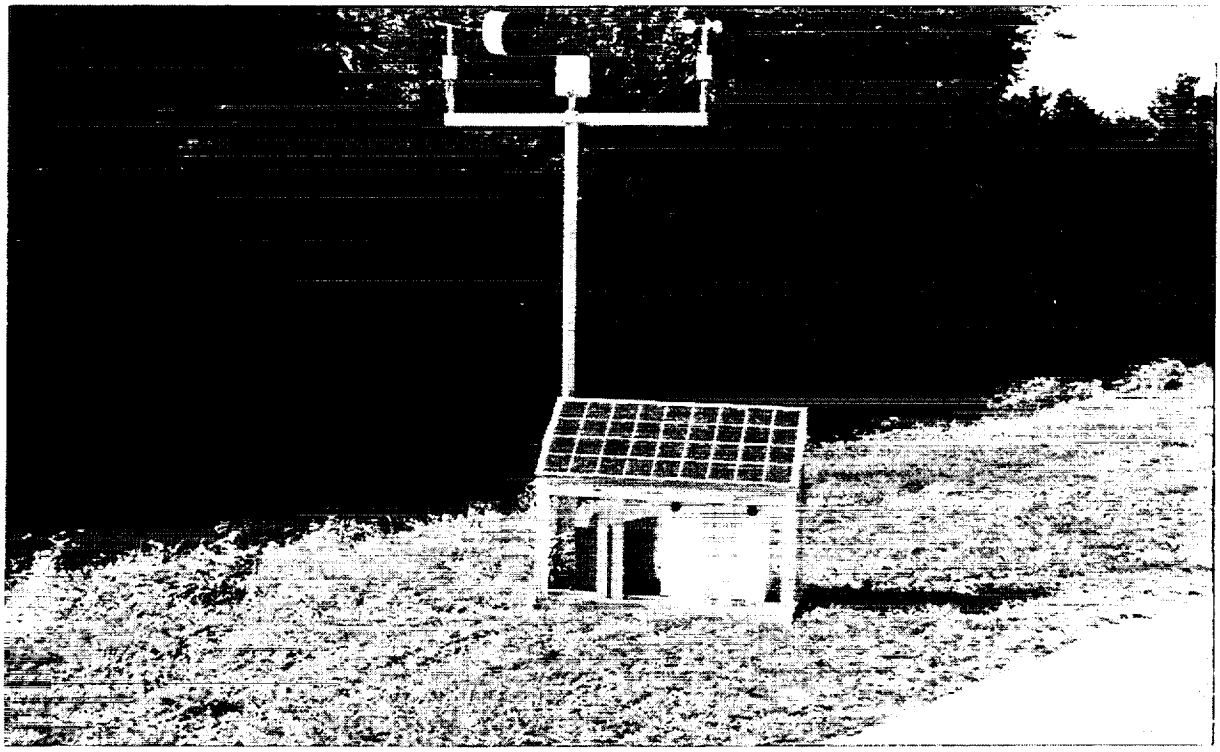
TECHNOLOGY OPPORTUNITY ANNOUNCEMENTS

NASA TECHNOLOGY TRANSFER

Commercial Applications of Aerospace Technology

Optical Broadcasting Wind Indicator

The National Aeronautics and Space Administration (NASA) seeks a partner to develop a commercial version of an Optical Broadcasting Wind Indicator. The instrument was invented by NASA Kennedy Space Center to provide a remote display of wind speed and direction more accurately than can be attained by viewing a windvane or windsock. The device broadcasts measured wind speed and direction information via optical flashes from a high intensity strobelight collocated with the sensors.



Product Profile

Users at Kennedy Space Center find that accessing wind direction from up to several miles distance enables them to perform a variety of tasks more safely and efficiently than before. For example, local surface wind speed and direction is needed for:

- aircraft pilots conducting low-level operations
- on-site safety officers establishing hazard zones and safety corridors during toxic material handling
- real-time weather observations during weather sensitive field operations.

The Optical Broadcasting Wind Indicator is intended for unmanned applications where greater precision or viewing distance is required than can be provided by a windsock. The instrument is not intended for commercial aviation applications where radiofrequency systems such as the Automated Surface Observation System are more appropriate. Instead, the Optical Broadcasting Wind Indicator may be used at general aviation airports and helicopter pads on buildings in metropolitan areas or at hospitals. Wind direction and speed monitoring for atmospheric plumes is another application for the instrument.

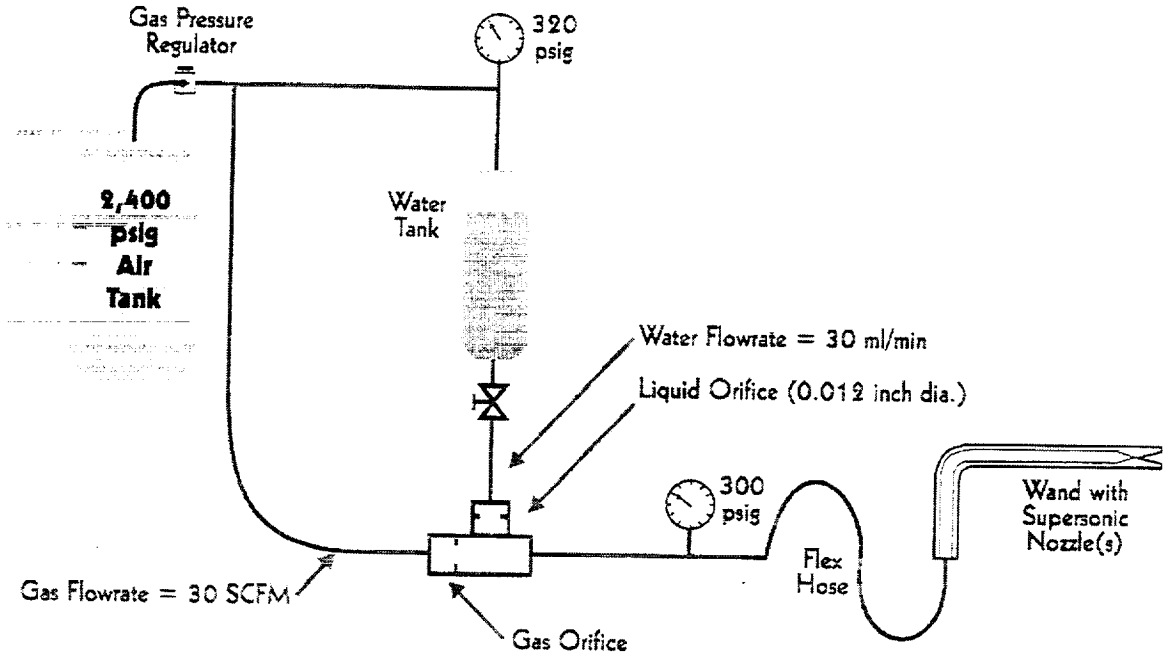
Technology Opportunity

NASA TECHNOLOGY TRANSFER
Commercial Applications of Aerospace Technology

Supersonic Gas-Liquid Cleaning System

Technology Opportunity

The National Aeronautics and Space Administration (NASA) seeks to transfer the NASA-developed supersonic cleaning system to industrial cleaning applications. The system, developed at the John F. Kennedy Space Center (KSC), is presently being implemented as a cleanliness verification tool in replacement CFC-113 rinsing. The system uses the high momentum of a supersonic air-liquid jet to remove contaminants from components while simultaneously emulsifying those contaminants into the liquid (typically water). The liquid can be collected and sampled for contaminants to verify cleanliness. Extremely low volumetric flow rates of liquid are required with this system. NASA seeks a company that is interested in developing this system for commercial cleaning and cleanliness verification operations.



Product Profile

The Supersonic Gas-Liquid Cleaning System was developed by NASA engineers to replace CFC-113 rinse cleaning and cleanliness verification methods. Equivalent or better performance of the new technique was verified by extensive testing using common contaminants (e.g. hydraulic oil and various greases) where removal efficiencies of better than 90% were achieved using air and water. The cleaning system uses less than 100 milliliters of liquid per square foot of cleaned surface area in its current configuration. Also, the operating pressure of 320 psi for this system is quite modest in comparison to other pressure-based systems. Used liquid can be collected for cleanliness verification.

The system (shown in the diagram) generates a supersonic gas-liquid stream that is directed at the surface to be cleaned. The high velocity of the mixture as it impinges on the surface has sufficient momentum to dislodge contaminants and emulsify them into the cleaning liquid. The liquid continuously drains off, leaving a clean surface. After a surface has been cleaned, the liquid supply may be turned off in order to use the pure gas stream as a drying agent.

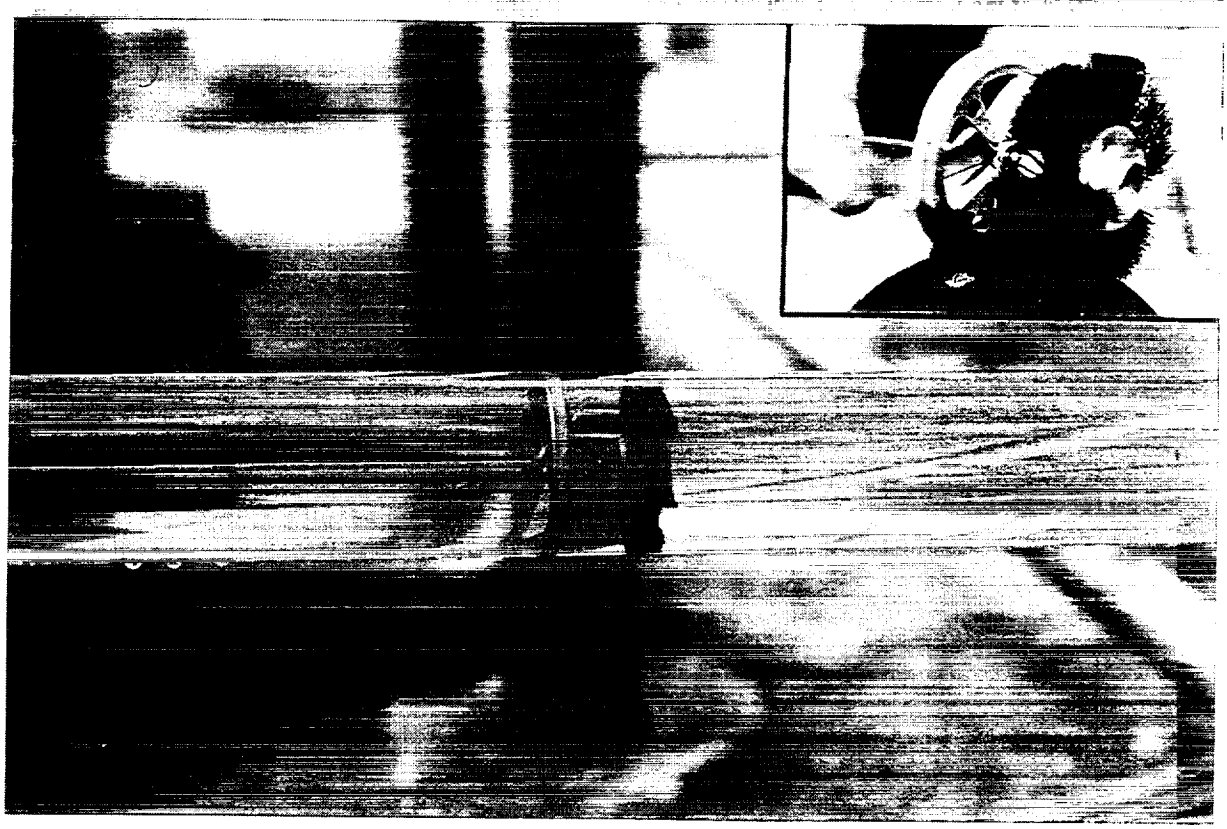
NASA TECHNOLOGY TRANSFER

Commercial Applications of Aerospace Technology

Turbine Brush Pipe Cleaner

Technology Opportunity

The National Aeronautics and Space Administration (NASA) seeks to transfer the Turbine Brush Cleaner process into commercial application as a pipe cleaning system. The enhanced cleaning action afforded by the turbine brush eliminates the use of chlorofluorocarbons, such as CFC-113, which harm the Earth's ozone layer. The system also provides for recycling of the water-based solution used for cleaning. NASA seeks a company for licensing or cooperative development to use this technology in commercial applications.



Product Profile

Pipe cleaning is important in almost every industrial location because internal build-up of contaminants restricts flow and increases power required to force fluid through the line. Reduced product purity and internal corrosion can result. While a number of commercially available methods for pipe cleaning exist, no single method works best in all applications. This document presents a recent invention of a Turbine Brush Cleaner that is able to traverse multiple 90 degree turns in small diameter pipes.

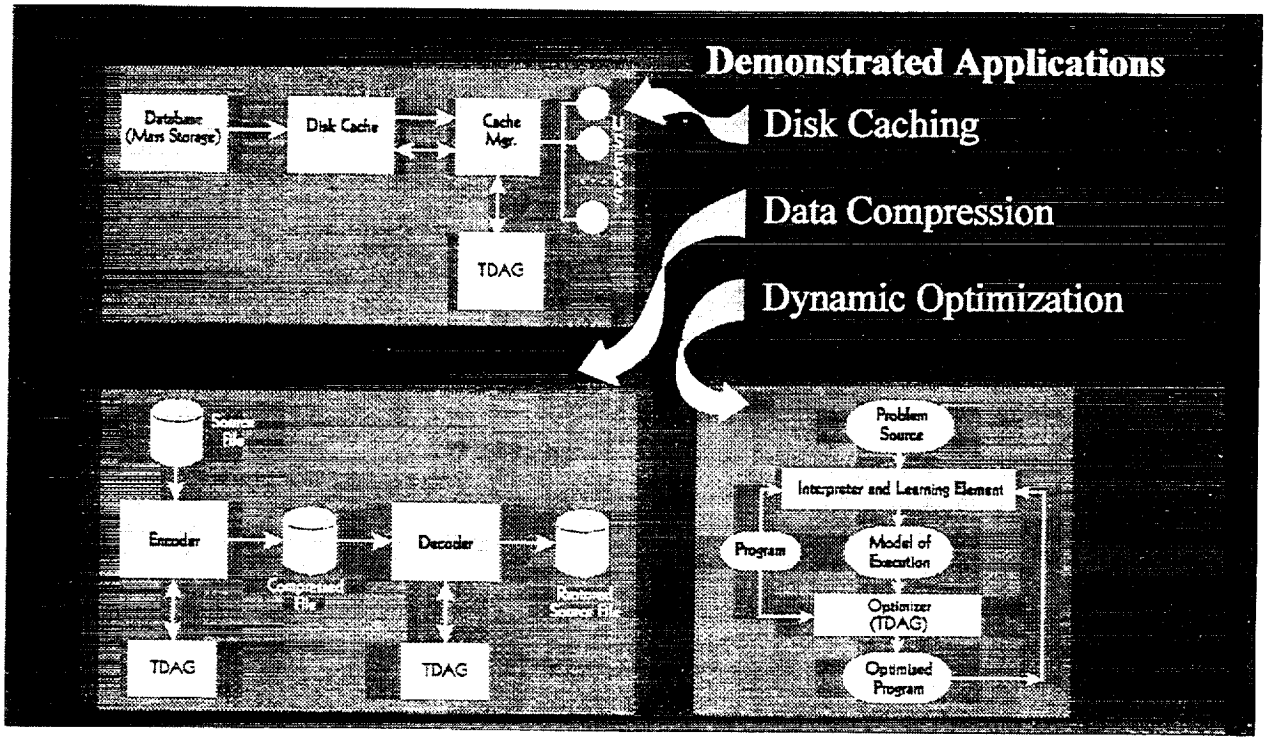
The Turbine Brush Cleaner uses a small turbine and bearing assembly that utilizes the upstream pressure of the aqueous cleaner solution to spin a standard circular brush used to clean the inside of pipes/tubes. Since the turbine brush uses the fluid flow through the pipe for power, a thin cable to control brush position replaces the mechanical drive cables or pneumatic or hydraulic pressure lines used to power previous systems of this type. The reduced friction of this thin cable allows the turbine brush to maneuver through t-sections and elbows over long distances.

NASA TECHNOLOGY TRANSFER
Commercial Applications of Aerospace Technology

Temporal Directed Acyclic Graph (TDAG)
Flexible Sequence-Learning Algorithm

Technology Opportunity

The National Aeronautics and Space Administration (NASA) seeks to transfer a flexible sequence-learning tool into commercial use. The algorithm has a number of applications, all based on the idea that, if the machine software can learn to anticipate what will happen, it can do its job more efficiently, just as transactions at an ATM machine are faster if the user is already familiar with its menus and responses. Researchers at Ames Research Center (ARC) have used the Temporal Directed Acyclic Graph (TDAG) algorithm to reduce program execution times, to compress text files, and to provide intelligent caching for more efficient data storage access. NASA is seeking a company or companies to apply this algorithm in commercial applications.



Product Profile

TDAG is a simple and practical algorithm that learns to predict sequences of discrete events. The task for discrete sequence prediction is to find statistical regularities in an input sequence so that, at any time, the next few input parameters can be predicted with better-than-chance likelihood. The TDAG technique has been refined to be fast, efficient, and highly adaptive to changes in the input.

TDAG has a number of potential uses. In three published demonstrations, TDAG was used as a predictive caching routine to reduce database access time, a technique for dynamic optimization of Prolog programs, and as a text compression algorithm.

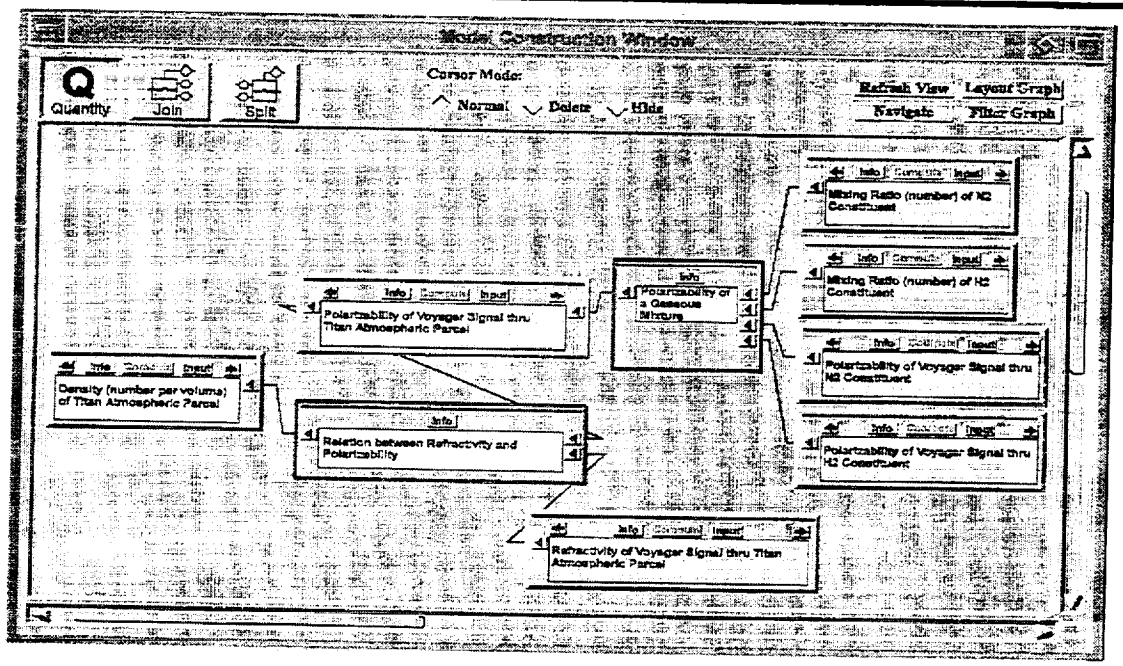
Disk caching is one way to reduce access times for mass storage devices. Small amounts of data can be stored temporarily in a high-speed storage cache while the bulk of the data remains on a mass storage system (MSS), usually disk or tape. Intelligent caching enables the cache manager to predict which portions of the data are most likely to be needed soon, and thereby to manage cache so that data transfer to and from the slower mass-storage device is minimized. The TDAG is ideal for predictions like these and is vastly superior to conventional predictive techniques like least-recently-used (LRU). Experiments clearly showed how TDAG can reduce access times for fetching data.

NASA TECHNOLOGY TRANSFER
Commercial Applications of Aerospace Technology

Scientists' Intelligent Graphical Modeling Assistant (SIGMA)
General Purpose Model-Building Tool

Technology Opportunity

The National Aeronautics and Space Administration (NASA) seeks to transfer a general purpose modeling tool into commercial use as an effective mechanism for prototyping scientific models. Researchers at the Ames Research Center have developed the Scientists' Intelligent Graphical Modeling Assistant (SIGMA) system, which has been used to create modeling codes that support several different scientific analyses. NASA is seeking a company to incorporate this tool into existing engineering and scientific software products.



SIGMA Model Construction Window

Product Profile

SIGMA is an interactive, knowledge-based, graphical software development environment that helps scientists to rapidly prototype their scientific models. The SIGMA tool is intended to simplify construction, modification, and reuse of modeling software, and to provide a supportive computational environment for exploratory model building. Despite the importance of modeling in the overall scientific process, scientists have little computational support available to help them perform this specific task. Recognizing this need, scientists at NASA have used representation and reasoning techniques from artificial intelligence to provide intelligent computational support for the modeler. Within the SIGMA environment, users create scientific models by configuring graphical building blocks that correspond to entities within a scientific model: equations, quantities, and datasets. The model itself is represented as a data dependency graph that illustrates how each derived model parameter is calculated from input parameters via a series of application equations.

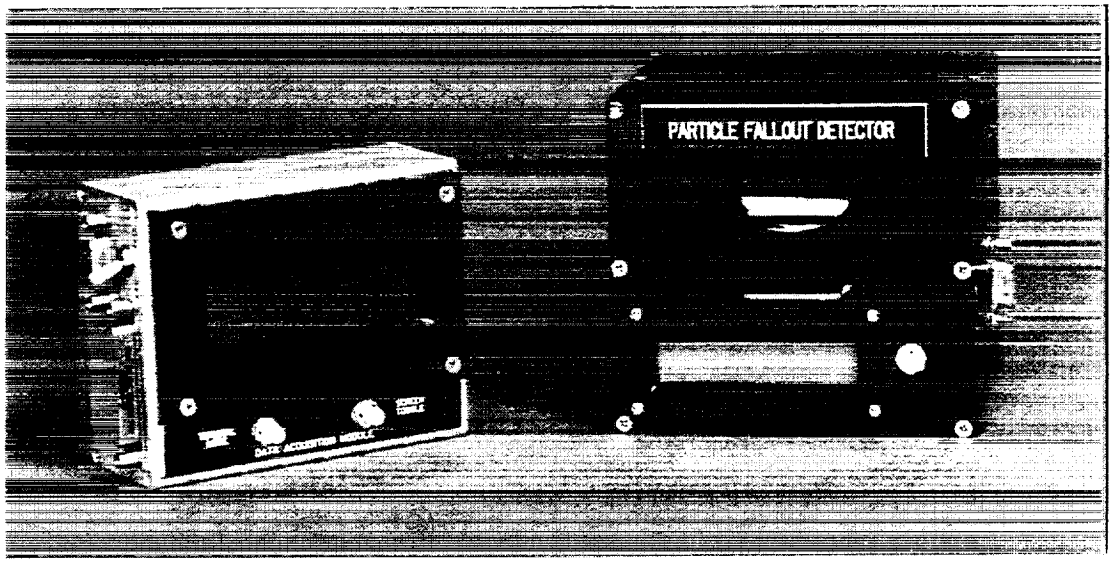
In contrast with more conventional model building, using SIGMA is simple and intuitive. SIGMA accelerates the scientific model building process and improves the accuracy and clarity of the scientific models produced. Rather than producing obtuse, low-level modeling code, SIGMA users construct high-level graphical structures that capture the essential scientific content necessary to understand a model. By interpreting these high-level structures in terms of its extensive background scientific knowledge, SIGMA can generate modeling results.

SIGMA's use of a high-level model specification language has many advantages. Peer review of scientific theory that is specified using SIGMA's language is much easier. Similarly, sharing of model fragments becomes more fea-

NASA TECHNOLOGY TRANSFER
Commercial Applications of Aerospace Technology

Particle Fallout Monitoring

The National Aeronautics and Space Administration (NASA) seeks to transfer a NASA-developed particle fallout monitoring system for commercial use in contamination monitoring or activity monitoring. The system, developed at the John F. Kennedy Space Center (KSC), is being used as a real-time contamination monitoring system to detect the accumulation of potentially damaging dust and fibers on sensitive payload components. In addition to its use as a fallout detector, the system has demonstrated effectiveness in monitoring activity versus inactivity based on recorded increases in fallout levels resulting from motion within a monitored area. The potential sensitivity of commercial systems may lend the technology to security monitoring. NASA seeks a company that is interested in developing or modifying this technology for commercial application.



Product Profile

The existing particle fallout system was developed by NASA engineers to replace a manual method for monitoring and measuring the accumulation of dust and other damaging particles on delicate payload components. The resulting real-time system can monitor and record the fallout activity in areas in which sensitive payloads are stored. The previous NASA system used witness plates and manual microscope examination to identify particles and amounts. To provide a real-time record of the fallout, the NASA system, which is battery operated and has memory capability, was designed using commercially available components.

The existing system is capable of measuring, recording with a time-tag, and downloading fallout levels in monitored areas. The system has a very low signal to noise ratio and thus excellent sensitivity. It can detect particle sizes of 0.2 microns and larger. The NASA system provides excellent results -- comparable with particle counts obtained with much more expensive instruments.

The Technology

The current design consists of two parts: the sensor module and the data acquisition module. The sensor module is constructed of black delrin, chosen for its optical properties. It has an opening in the top through which dust can fall and settle onto a test mirror. An infrared light-emitting diode (LED) with a limiting

Technology Opportunity

Table 1: Selected Polyimide Properties

Selected Polyimide Films	Film Color (0.5 mil thick)	Glass Transition Temp. (°C) by TMA	Polymer Decomp. Temp. (°C) by TGA	Dielectric Constant at 10 GHz	Change in Dielectric Constant 30-100% RH	Solubility in DMF/DMAc, $CHCL_3$, and DIGLYME
LaRC-CP1™	colorless - pale yellow	263	530	2.50	1% increase	soluble
LaRC-CP2™	colorless - pale yellow	206	550	2.67	-	soluble
LaRC-CP3™	colorless	279	520	2.86	-	soluble
Kapton H®	bright yellow	-	542	3.22	14% increase	insoluble

In the mid- to late seventies, NASA began researching methods for reducing the possibility of inter- and intramolecular complex formation in polyimide materials. NASA believed these charge transfer complexes were responsible for the yellow polyimide color. Linear aromatic polyimide films and coatings were prepared by the polymerization of a highly purified aromatic diamine monomer and a highly purified dianhydride monomer in a solvent medium. This new process involved two conditions: (1) purification of both of the reactants and the solvent, and (2) elimination of chromaphoric centers and reduction of both inter- and intra- chain electronic interactions. The resulting polymer films were 80-100% transparent in the visible spectrum (400-600 nm), a 100% or greater improvement over commercially available polyimides. Specific properties of selected films are presented in Table 1.

As part of this research, NASA introduced fluorine containing groups to the polyimide backbone thus producing transparent polymers that were highly electrically insulative and resistant to moisture. NASA's investigation of over 100 polymers has resulted in numerous linear polyimides that exhibit low dielectric constants in the range of 2.4 to 2.8 at 10 GHz. From a performance standpoint, these polyimides have the potential to be superior to the commercially available polyimides currently used as materials for wire coating, flexible printed circuit boards, and multichip module interlevel dielectrics.

Benefits

- Optically transparent at 400-600 nm wavelength
- Thermal use temperature of 300 °C
- Low dielectric constant (2.4 - 2.8 @ 10 GHz)
- Good resistance to ultraviolet, electron, and proton irradiation
- Low water absorption
- Soluble in a variety of organic solvents

Applications

- Flexible printed circuit boards
- Solar cells and arrays
- Thermal control coatings
- Wire coatings
- Multichip module interlayer dielectrics

Technology Transfer Status

NASA has received two U.S. patents on the colorless polyimide materials.

- U.S. Patent No. 4,595,548 dated June 17, 1986. Process for Colorless Polyimide using Phenoxy-Linked Diamines.
- U.S. Patent No. 4,603,061 dated July 29, 1986. Process for Preparing Highly Optically Transparent/Colorless Aromatic Polyimide Films.

NASA has also applied for two U.S. patents on the low dielectric polyimide materials.

The NASA Langley Research Center seeks a commercial partner to license the technology and develop commercial applications. The opportunity for cooperative research and development between NASA and the commercial partner under a NASA Space Act Agreement is also available.

Contact

If your company is interested in the Colorless and Low Dielectric Polyimide Thin Film Technology, or if you require additional information, please contact the NASA Technology Applications Team:

Molly O'Donovan Dix
Research Triangle Institute
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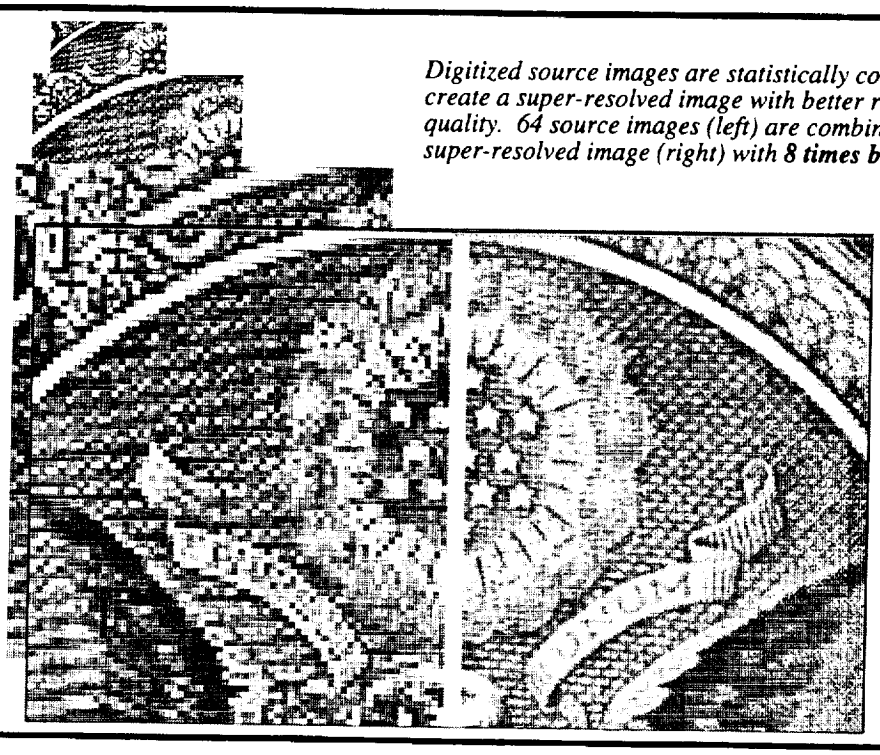
NASA TECHNOLOGY TRANSFER
Commercial Applications of Aerospace Technology

Super-Resolved Image Processing Software

Technology Opportunity

The National Aeronautics and Space Administration seeks partners to commercialize image processing software that improves both spatial and gray scale resolution. The software was developed by the NASA Ames Research Center as a cost-effective way to improve the quality of images from space probes. It solves image quality problems by creating one super-resolved image from several images. As the number of digitized source images increases, the software produces even better quality final images. NASA seeks an active development partner to adapt the code and take it to market.



*Digitized source images are statistically combined to create a super-resolved image with better resolution and quality. 64 source images (left) are combined to create a super-resolved image (right) with **8 times better resolution.***

Product Profile

Image quality is affected by distance, object/camera orientation, environmental conditions, and camera quality. It is often impractical to try to overcome these problems with a better camera, a better vantage point, or changes in conditions.

Super-Resolved Image Processing Software (S-RIPS) uses a number of source images of the same object (but from slightly different perspectives) to make a final image of higher quality. Both spatial and gray scale resolution are improved. Four source images will result in a final super-resolved image with double the resolution of the original images. Sixty four images will yield eight times the resolution in the final product.

Any set of digitized images of the same area can be processed. Only the digitized images and the software are required. However, additional information, such as knowledge of the camera characteristics, can speed the processing. This research code currently runs on Symbolics Lisp machine.

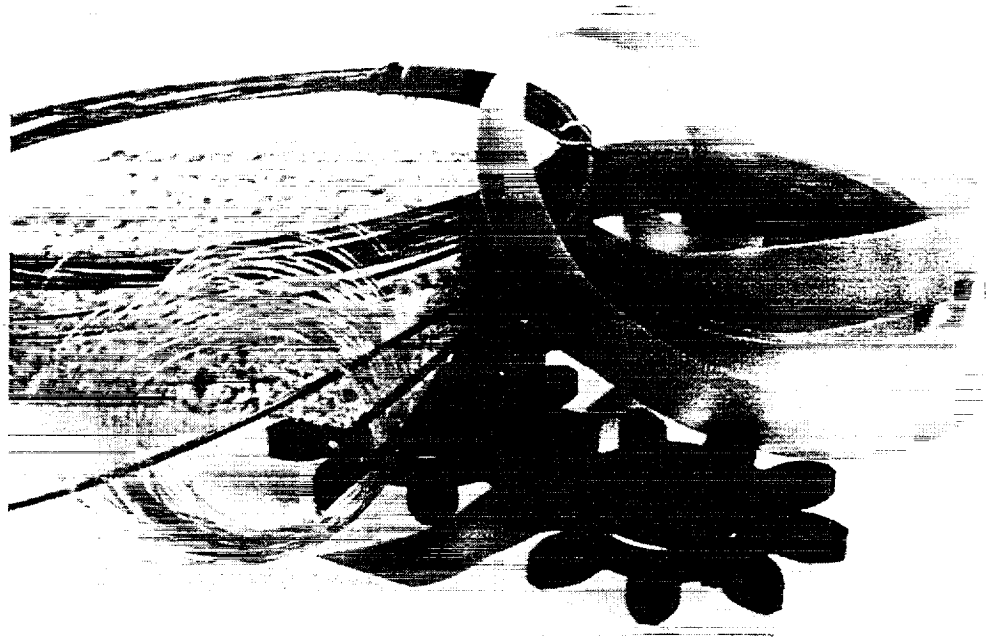
Benefits

Reduced Expense: Image quality is improved by using software to process multiple images. Compared to more

NASA TECHNOLOGY TRANSFER
Commercial Applications of Aerospace Technology

LaRC™ -IA
Tough, melt-processable, thermoplastic polyimide

The National Aeronautics and Space Administration (NASA) seeks to transfer into the commercial sector a NASA-developed thermoplastic polyimide material: LaRC™ -IA, "improved adhesive." Originally developed as a less expensive alternative to existing polyimide adhesive materials, LaRC™ -IA lends itself to numerous other applications. This material, developed at NASA's Langley Research Center (LaRC), can be used as an adhesive, film, molding, composite, fiber, coating, and foam. NASA seeks companies interested in using the material for commercial applications.



Although designed as an adhesive, LARC™ -IA demonstrates excellent properties as a film, molding, composite, fiber, coating, and foam.

NASA Technology

LaRC™ -IA is a linear, aromatic, thermoplastic polyimide prepared from oxydiphthalic anhydride and 3,4'-oxydianiline. LaRC™ -IA was originally developed as an inexpensive alternative to LaRC™ -TPI for use as a high temperature adhesive for supersonic aircraft structural applications. LaRC™ -IA is currently a leading candidate in NASA's research to develop composite and bond structures for these supersonic applications. Films and coatings have exhibited outstanding performances in simulated space environments; specifically, excellent stability to UV exposure.

Applications

Although designed as an adhesive, the NASA-developed material exhibits outstanding properties in numerous other forms including:

- bondings (film and solution)
- films
- moldings
- composites
- fibers
- coatings
- foams.

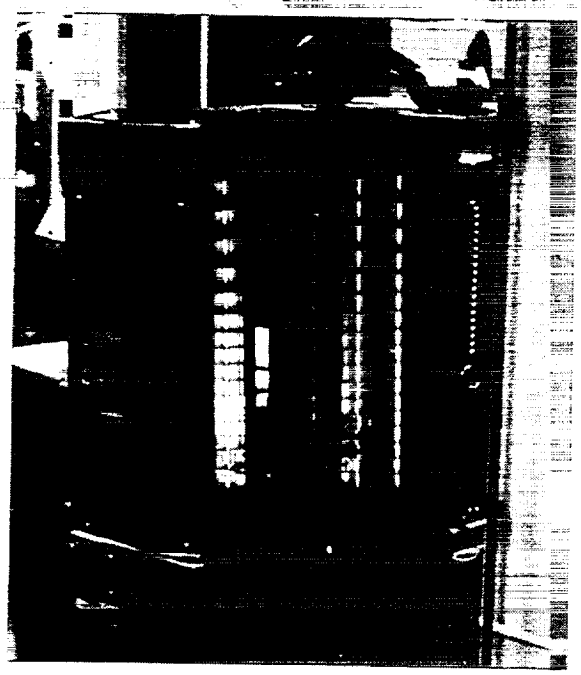
Technology Opportunity

RTI

NASA TECHNOLOGY TRANSFER
Commercial Applications of Aerospace Technology

LaRC™ -IA
Thermoplastic Polyimide Adhesive

The National Aeronautics and Space Administration (NASA) seeks to transfer into the commercial sector a NASA-developed thermoplastic polyimide adhesive: LaRC™ -IA, "improved adhesive." This new material was developed at NASA's Langley Research Center (LaRC) as an inexpensive alternative to existing polyimide adhesive materials required for supersonic aircraft applications. The adhesive can be used as a strip solder, hot-melt tape, or bonding solution. Also, this material can be used as a film, molding, fiber, foam, or composite. Please contact NASA as indicated on the back of this sheet if you have any interest in using LaRC™ -IA in a commercial application.



A lap shear strength test specimen bonded with LaRC™ -IA is tested on a universal testing machine. LaRC™ -IA demonstrates excellent shear strength due to its hot-melt flow characteristics. Lap shear specimens have resulted in strengths greater than 9,000 psi.

NASA Technology

LaRC™ -IA is a cost-effective thermoplastic that was developed initially as a high temperature adhesive for supersonic aircraft structural applications. Because of the unusual meta- and para- bond linkages in the diamine from which it is prepared, LaRC™ -IA exhibits intrinsic molecular weight control that makes it highly processable via hot-melt techniques. No other fully aromatic linear polyimide exhibits the level of melt flow at such a low temperature (325-350°C).

LaRC™ -IA demonstrates excellent thermal stability with a glass transition temperature (T_g) of 232°C. The material is stable under ultraviolet exposure, and solvent resistant. The chemicals used to make LaRC™ -IA are nontoxic, noncarcinogenic, and available from U.S. sources. The by-products of manufacture are recyclable with a major component being water. The estimated cost of the material at a production level of one million pounds per year is $10 per pound.

Adhesive Properties

The adhesive properties of LaRC™ -IA are attributed to the high degree of flexibility in the polymer backbone. This flexibility is afforded by the bridged dianhydride and the meta-linked diamine.

The primary test used for evaluating LaRC™ -IA as an adhesive has been lap shear strength (LSS) testing according to ASTM D1002. Tests have been completed at room

Technology Opportunity

COMMERCIAL OPPORTUNITY PROGRAM (COOPPR)

The Langley Research Center's Commercial Opportunity Program implements NASA's management philosophy for enhancing utilization of government developed technology by the private sector. It does so by integrating the combined interests and talents of Langley management, technical staff, and the Technology Applications Group to match potential manufacturers with identified NASA proprietary technologies available for licensing and commercialization.

1. HOW THE PROGRAM WORKS

An advanced notice published in the *Commerce Business Daily* briefly describes the new technology and invites American companies to submit to NASA an expression of interest in commercializing the technology and a statement of their qualifications.

Qualifications should include experience and competence in related technologies; related manufacturing capabilities; track record in commercializing similar products; marketing organization; and financial condition of the firm. Those companies found to be qualified will be invited to a technology briefing on the selected technology package. Companies interested in joining with NASA in a Joint Space Act Development and Commercialization Agreement with accompanying license agreement will be invited to submit proposals.

Thus, Langley's Commercial Opportunity Program leads to a working partnership between industry and NASA to transfer advanced and commercially valuable technology to the private sector for commercial product applications.

2. WHAT YOU NEED TO DO

Companies interested in the Low Temperature Oxidation Catalysts should first submit a letter expressing their interest in commercializing the technology. The Statement of Interest and Qualifications should include the following information.

1. Name, address, and place of incorporation of your company.
2. Name, telephone number, and fax number of your company contact.
3. Current Dun & Bradstreet Report and/or your company's most recent Annual Report.
4. Description of the nature and type of your company's business including your company's experience in catalyst materials production or applications..
5. Description of related products and/or services developed by your company.
6. Description of your company's management experience, manufacturing capabilities, and marketing organization.
7. Approximate number of employees.

Statements of Interest and Qualifications should be sent by September 23, 1994 to:

NASA Langley Research Center
Technology Applications Group
Attn: Dr. Frank Farmer
Mail Stop 200
Hampton, VA 23681-0001
TEL: (804) 864-2490
FAX: (804) 864-8314

All business information submitted and marked CONFIDENTIAL will be maintained in confidence. All business information and all copies thereof will be returned upon request. Companies submitting complete Statements of Interest and Qualifications will be invited to attend the briefing. Letters of invitation, including background information, will be mailed three weeks prior to the briefing.

3. WHAT YOU NEED TO KNOW

It is NASA's intention to commercialize this technology by patent license and/or Joint Space Act Development and Commercialization Agreement. Following the briefing, companies will be invited to submit a business proposal for a joint development and patent license agreement to Dr. George Helfrich, Langley Research Center, Mail Stop 212, Hampton, VA 23681-0001.

The business proposals will be reviewed by an in-house evaluation team of civil service NASA employees composed of a representative from the following: the Langley Experimental Testing Technology Division technical program, Langley Experimental Testing Technology Division management, and the Technology Applications Group. The evaluation team may consult with outside advisors as required. Following selection, a *Federal Register* notice of intent to grant license will be published.

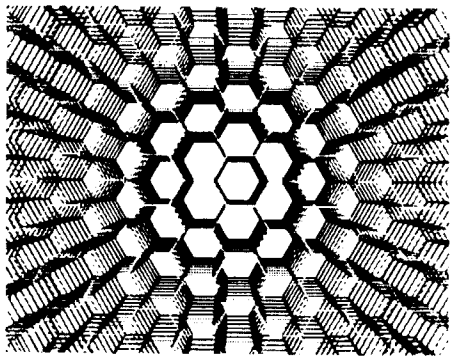
Selection of the NASA commercial partner will be based on the following criteria:

1. Record of successful technology developments leading to commercial products.
2. Clear work/business plan; well defined roadmap to commercialization.
3. Marketing ability as demonstrated by past success and future plans.
4. Project management approach.
5. Facilities.
6. Staff technical experience/expertise.
7. Financial condition of the firm; ability of the firm to bring capital to the project. We do not plan for the proposal to involve NASA funding in support of this activity.
8. Ability of the firm to leverage (join forces) with other firms needed to provide overall commercialization success.

Low Temperature Oxidation Catalysts

Team with NASA...

Commercial opportunities through technology utilization.



National Aeronautics and Space Administration

Langley Research Center
Hampton, VA 23681