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TECHNOLOGY APPLICATIONS TEAM
APPLICATIONS OF AEROSPACE TECHNOLOGY

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TECHNOLOGY APPLICATIONS TEAM
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Annual Report
(October 1990 - September 1991)

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1.0 INTRODUCTION

This report covers the activities of the Research Triangle Institute (RTI) Technology Applications Team for the period 1 October 1990 through 30 September 1991. The work reported herein was supported by the National Aeronautics and Space Administration (NASA), Contract No. NASW-4367. Mr. Ray L. Gilbert, NASA Headquarters, was the technical monitor. The work was performed in the RTI Center for Technology Applications under the direction of Dr. D. J. Rouse. Other participants in the program were Dr. John Cleland, Mr. Dean Hering, Mr. Stephen Lehrman, Mr. Stephen Mangum, Mr. Robert Wallace, Mr. Daniel Winfield, Mr. Jeff Antley and Ms. Nancy Court. RTI consultants participating during the reporting period were Mr. Reed Barnett, Mr. Aubrey Smith, and Mr. Gerald Warren..

The Technology Applications Team supports all NASA Centers in developing applications engineering projects to transfer NASA technology to non-aerospace applications. Highlights of the RTI Applications Team activities over the past year are presented in Section 2.0. In accordance with our proposed technical approach, RTI undertakes several new initiatives each year to focus technology transfer efforts to industries in significant need of new technologies. Current initiatives are discussed in detail in Section 3.0. The Team's progress in fulfilling the requirements of the contract is summarized in Section 4.0. Section 5.0 summarizes the status of the four add-on tasks. New problem statements prepared by the Team in the reporting period are presented in Section 6.0. Two new problem statements were developed by the RTI Team under the auspices of a subcontract from Martin Marietta to assist in the development of commercial applications for Flight Telerobotic Servicer technology. Because these problem statements are relevant to the overall NASA TU program, they warrant review by NASA TU officials and are presented in Section 6.0 of this report. The Team's transfer activities for ongoing projects with the NASA Centers are presented in Section 7.0. Travel for the reporting period is described in Section 8.0. The RTI Team staff and consultants and their project responsibilities are listed in Appendix A.

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

SECTION 1.0: INTRODUCTION

The RTI Team looks forward to continuing expansion of its interaction with U.S. industry to facilitate the transfer of aerospace technology to the private sector.

2.0 HIGHLIGHTS

Outreach

- The RTI Applications Team has participated in several meetings with the **National Center for Manufacturing Sciences (NCMS)** to discuss technical areas of mutual interest to both NASA and NCMS. Two new technology transfer initiatives between NASA and NCMS have commenced: (1) The RTI Applications Team sent a letter requesting each NASA Field Center to submit topics for one-day Technology Transfer Workshops, and (2) a Memorandum of Understanding between NASA and NCMS to collaborate on technology transfer has been drafted. This initiative is discussed in detail in the Major Initiatives section. (p. 18)
- The RTI Applications Team began a new initiative with the **U.S. Conference of Mayors (USCM)** to discuss the possibility of working with NASA Field Centers to transfer NASA technology to meet the needs of cities. Subsequently, the Team traveled to the cities of **Knoxville, TN** and **Houston, TX** to discuss with high-level city officials the NASA/USCM initiative. Brief problem summaries, submitted by Houston and Knoxville, have been reviewed by the Team and responses provided to each city. This initiative is discussed in detail in the Major Initiatives section. (p. 21)
- The Team initiated a new Technology Transfer effort with the **Center for Special Education Technology**. Through a series of telephone conference calls with special education technologists and practitioners we identified three priority problems that may benefit from the use of NASA technology. Solutions to these problem areas would allow students with disabilities to participate with other school children in classroom instruction and activities which might have otherwise been denied to them. This initiative is discussed in detail in the Major Initiatives section. (p. 31)
- RTI is developing an active collaboration with the **National Cancer Institute Diagnostic Imaging Research Branch** to identify areas for technology application to medical imaging. This initiative is discussed in detail in the Major Initiatives section. (p. 28)

Responses to two problem statements were reviewed by a NCI Cooperative Working Group on Radiation Treatment Planning. This Group requested Stennis Space Center conduct a pilot study to test the feasibility of the image segmentation techniques which they proposed to use for object definition in CT images. (p. 171)

SECTION 2.0: HIGHLIGHTS

More recently the **National Cancer Institute** requested RTI to participate in a workshop on Imaging Guided Stereotactic Diagnosis and Treatment. Because of the parallels between this field and telerobotics, we arranged for Dr. Paul Schenker of JPL to participate also.

Motivated by the promise of these initial interactions, we have worked with Dr. Faina Shtern of NCI to draft a **Memorandum of Understanding** between the NASA Technology Utilization Division and the **National Cancer Institute** Diagnostic Imaging Research Branch to identify areas for technology application to medical imaging.

On a related topic, RTI provided information on applications of space technology to medical image processing for an article published in the July 17, 1991 issue of the *Journal of the National Cancer Institute*.

- At the request of **Johnson Space Center**, RTI assisted in the planning of a workshop with the **Limbs of Love Foundation** to discuss plans for a new initiative to develop a next generation myoelectric prosthesis for children and adults with upper limb loss. RTI served as moderator for the workshop which was highly successful both in delineating areas for technology advancement and in soliciting volunteers to prepare summary need statements. RTI published the report from the workshop and will serve as interface to NASA in seeking solutions to the needs defined in the summary statements. This initiative is discussed in detail in the Major Initiatives section. (p. 35)
- RTI has initiated interaction with the **National Aerospace Plane Technology Transfer Office**, Wright Patterson Air Force Base Joint Projects Office (JPO coordinates both Air Force and NASA activities on the NASP). The Applications Team has reviewed NASP material and **designated 17 NASP project activities** within the government work package that should be first priority for technology transfer. The Team has talked with Air Force reservists who are organizing workshops for technology transfer and offered advice for workshop organization. RTI has sent information on industry contacts to SAIC. Coordination with the NASP program has also allowed initial contacts with the 65 member materials consortium associated with one of the Edison centers in Cincinnati, Ohio and with the new DARPA-funded \$100 million materials facility.
- RTI is participating on an **Expert Panel on Technologies for Sensory Impairment**. This panel serves to advise the Science Applications International Corp. during their research study for the Dept. of Education. Following a meeting of this panel in February, we have worked with SAIC to develop a problem statement for a full page, refreshable braille display for computer access for the blind. (p. 78)

- Three new problem statements in the rehabilitation field have now been distributed as a result of RTI outreach efforts with the **National Easter Seal Society**. These include Improved Telecommunications Technology for the Hearing Impaired; Durability and Reliability of Externally Powered Elbow Prostheses; and Suspension for Wheelchairs. A project has been initiated at Marshall Space Flight Center to develop an improved suspension system for wheelchairs. (p. 92, 82, 160)
- The RTI Applications Team has started a new initiative with the Civil Engineering Research Foundation to look for NASA technology that would benefit the civil engineering community. We participated in the **Civil Engineering Research Needs Forum**, Thrust Area 5 Panel on Technology Transfer, in Washington, D.C. This forum, attended by over 250 participants, focused on five major thrust areas including revitalization of the public works infrastructure, improving the competitiveness of the U.S. design and construction industry, enhancing the environment, developing innovative technologies and systems, and technology transfer. This initiative is discussed in detail in the Major Initiatives section. (p. 25)
- The Team, with Mr. Ray Gilbert, participated in the **Hardwood User's Requirements Committee Meeting** in Beltsville, MD in March 1991. Industry representatives from the Hardwood Research Council presented twenty-eight issues confronting the hardwood industry. Federal laboratory representatives and the Team then discussed the technical details of the problems with the hardwood personnel. The Team sent materials to the problem area task leaders to assist them in writing Problem Statements. Solutions to these problems impact conservation, energy, waste, and disease aspects of the hardwood industry. (p. 116)
- The Applications Team met with Mr. Peter Crimes, Director of Technology, **American Mining Congress**, at NASA HQ on May 28. AMC (with a staff of about 55) represents approximately 300 of the major mining operations, equipment, supply, financing, and consulting firms in the mining industry. They would like to examine NASA technology to augment the areas of exploration, mining, ore extraction and processing. Mr. Ray Gilbert represented the NASA TU Office at the meeting.
- The Team participated in the **Florida Council High Tech Day** to assist Kennedy Space Center TU staff in fostering technology transfer to Florida companies. The team assisted at the Kennedy booth in answering questions and promoting technology utilization. Separate discussions were held between the Team and representatives from AT&T, Motorola, Harris, and the American Electronics Association to discuss technology transfer mechanisms with NASA. Meetings

SECTION 2.0: HIGHLIGHTS

such as High Tech Day involve state representatives and companies, giving exposure to technology opportunities at NASA through the TU program.

- The Team participated in the **Utilities/Manufacturers Robotics Users Group (U/M RUG)** meeting in Albuquerque, New Mexico in March 1991. U/M RUG is in the process of defining robotic activities, research and development in and for utilities. The Team discussed the program with a number of utilities and utility service representatives and Harry Roman, Chairman of U/M RUG. NASA robotics, sensing, and measuring technologies may potentially provide solutions to some of the utility needs.
- The RTI Team participated in several meetings with the **American Diabetes Association (ADA)** and drafted a **MOU between ADA and NASA** for collaborative efforts to develop applications engineering projects.
- A paper written by RTI Team members entitled "**NASA Spinoffs to Bioengineering and Medicine**" was published in *Acta Astronautica* Vol. 25, No. 2, pp. 103-110, 1991.
- An article by the RTI Team, "**Spin-Offs from Space: Health on Earth,**" was published in the *Encyclopedia Britannica Medical and Health Annual 1991* in November 1990.
- The Team worked with two industry associations, the **Independent Lubricant Manufacturers Association (ILMA)** and the **American Society of Mechanical Engineers**, to define an important environmental problem concerning the removal of nonionic surfactants from metal cutting lubricants and waste material. In response to a NASA Problem Statement, Dr. Ted Wydevan of NASA Ames proposed using their Supercritical Water Oxidation Reactor to treat the contaminated material. The Team is working with ILMA to define a project plan and identify other sources for project cofunding. (p. 133)
- The RTI Applications Team represented the NASA Technology Utilization Program at the **National Defense Manufacturing Technology Program Task Force 4** meeting at the National Institute of Standards and Technology in Gaithersburg, MD. The purpose of the meeting was to discuss how extension services could be used to transfer MANTECH sponsored technology to industry.
- RTI presented "The NASA Technology Utilization Program: An Overview" to the **Public Service Electric and Gas Company** in New Jersey. The presentation has led to a proposal from PSE&G to use their Advanced Technology Center as a technology transfer and training center for educators and industry in New Jersey. The RTI Applications Team is working with PSE&G on a draft document outlining the scope of this proposal.

- RTI presented "The NASA Technology Utilization Program: An Overview" at the **New Business Opportunities in Drug Interdiction Symposium** in Los Angeles, CA. This meeting represented an opportunity for NASA to discuss its collaboration with the Department of Justice to apply aerospace technology to prison systems.
- RTI made a presentation on "NASA Technology; Innovative Applications in Corrections," at the **American Correction Conference in Louisville** on January 16.
- The Team contacted Dr. Gail Schwartz of the **Department of Education Office of Correctional Education** and Mrs. Linda Roberts of the **Office of Technology Assessment** to inform them of the Johnson Space Center **Adult Literacy Tutor**. Dr. Schwartz heads a new office in the Department of Education responsible for educating prisoners in federal, state and local prison systems. The Team is working with Dr. Schwartz and Kevin Jackson of the National Institute of Corrections to define a demonstration project for the Literacy Tutor. Mrs. Roberts is preparing an OTA report for the U.S. Congress concerning the application of technology to literacy and education. Stephen Lehrman also presented the **Johnson Space Center Literacy Tutor project** to the Director and staff of the **Southern Policies Board**. This group responds to requests from the governors of ten Southeastern U.S. states. Literacy and education is a priority area of this organization. (p. 135)
- RTI participated in the **American Society of Mechanical Engineers Technology Opportunities and Planning Committee Meeting**. Representatives of the Volunteers for Medical Engineering and the Mississippi State University Diagnostic Instrumentation Applications Laboratory met with the Team to discuss applying NASA technology.
- The RTI Team presented *Technology Transfer: A Designer's Tool* at the **Institute of Electrical and Electronics Engineers (IEEE) Southeastern Conference** in Williamsburg, VA. The paper focuses on issues of interest to design engineers when applying federally developed technology and uses Applications Projects and Spinoffs as examples. Discussions with NASA researchers resulted in a request from NASA Langley Research Center engineers to assist in locating potential corporate partners for the Convolver for Real-time Image and Signal Processing (CRISP) technology at NASA LaRC. (p. 114)
- The RTI Applications Team has taken a more active involvement in the **Federal Laboratory Consortium** in order to share technology transfer strategies with other Federal Lab technology transfer specialists. Doris Rouse attended the FLC meeting in New Orleans in November, while Steve Lehrman and Dan Winfield attended the FLC Spring 1991 meeting in San Diego, CA.

SECTION 2.0: HIGHLIGHTS

- The Team met with Dr. Bert Cunningham, a University Scholar from Griffith University, Australia, who is on leave to **IC² at the University of Texas in Austin**. Dr. Cunningham is researching U.S. technology transfer activities and organizations and is planning a publication in which the NASA TU program will be featured.
- The RTI Applications Team began discussions with the **Delaware Technology Park** regarding a framework for NASA, the companies in and around the Park, and the University of Delaware Center for Composite Materials to collaborate on technology transfer of NASA composite materials technology.
- The RTI Team made a presentation on the Applications Engineering Program to **Code M staff at NASA HQ**.
- The entire RTI Applications Team participated in **Technology 2000**. Doris Rouse made a presentation on the Applications Engineering Program.
- Doris Rouse made a presentation on the "NASA Technology Application Program" on June 10 at the **Technology Transfer Society Conference** in Denver, Colorado.

Projects

- To document the outcome of an Applications Engineering Project, RTI spoke with its contacts at **Texas Instruments, Inc.** to obtain product literature on the **DMD Printer for Airline Boarding Pass Printing**. This product incorporated technology involved in a joint JSC/Texas Instruments application project. RTI also drafted a Spinoff story with contact names and numbers for CASI.
- RTI continues to support the **NASA/American Cancer Society-Florida Division program** which has proven quite productive. This program is discussed in detail in the Major Initiatives section (p. 38). New project actions during FY 91 include:

MSFC (Laurel Karr) submitted a project statement to develop a **flow-through immunoaffinity device for separation of tumor cells from normal cells**. This device, based upon research into microgravity cell separation, could have applications in autologous bone marrow transplantation. RTI assisted the investigators in evaluating the proposed concept and in developing a proposal, submitted to ACS for co-funding. (p. 54)

At the suggestion of RTI, the **Jet Propulsion Laboratory** (Robert Selzer) submitted a project statement to develop a **video screening system for detection of melanoma** in patients with dysplastic nevi (moles). The ACS-Florida is enthusiastic about this concept, and a full proposal for co-funding of this project has been submitted. However, JPL has elected to allocate all TU funding to the Technology Affiliates Program so NASA funding is now in doubt. (p. 180)

ACS has identified an investigator, Dr. James Daughtry, for a project to develop a **panoramic cystoscopy display** system. RTI identified applicable technology at the University of Alabama-Huntsville in work conducted for Marshall Space Flight Center. RTI is working with Dr. Daughtry to develop a project plan. (p. 148)

RATCOM, Inc. has completed a design for a new **flow cytometer** to meet the needs of NASA Life Sciences and the needs in clinical oncology as defined by the ACS investigators. Both JSC and ACS have conducted design reviews. The first prototype unit will be delivered to NASA in January 1992, and ACS funding will be used to purchase a second unit for testing in oncology applications at the University of Miami. (p. 169)

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RTI has worked with Glenn Spaulding of Johnson Space Center in submitting a project statement to ACS-FL for the **rotating cell culture vessel** technology. ACS-FL has identified several potential cancer research collaborators. Their concepts will be reviewed in November 1991, and RTI will assist JSC and the selected collaborator(s) to develop complete project plans. (p. 129)

- The **Wanderer Notification System** project at **Johnson Space Center** has been successfully completed. The system was developed to assist in the management of wandering behavior by Alzheimer patients and others in the home and institutional environments. On November 27, 1990 at NASA HQ Code C, the manufacturer, Cortrex Electronics, demonstrated the system to the cofunding agencies: **Administration on Aging, National Institute on Aging, National Institute on Disability and Rehabilitation Research, Department of Veterans Affairs** and NASA. RTI's role in this project included defining the requirements, conducting a feasibility study, coordinating agency meetings, assisting JSC in selection of the manufacturer and documenting the process and results. (p. 164)
- The **Wilmer Eye Institute of Johns Hopkins University** received a multi-year grant from the **Veterans Administration** to test the **Low Vision Enhancement System** being developed with **Stennis Space Center**. Along with additional private funding allocated by Johns Hopkins and The Dome Corporation, total co-funding for this project through 1992 will exceed \$6 million, including \$990,000 in reimbursable funding to NASA. NASA TU funding for this period will total \$700,000.
- Doris Rouse met with Dr. Basil Pruitt and other burn surgeons at Brooke Army Medical Center to discuss evaluation of the **NASA Langley burn depth monitor**. The unit was demonstrated at the Critical Care Conference in Baltimore in March, and commercial orders have been taken by **FDI-Westminster, Inc.**
- With input from the **Center for Special Education Technology** expert panel and five industry representatives, the RTI Team developed a problem statement on **monitoring of medically fragile children**. Two groups at Johnson Space Center responded with promising technologies in the problem areas. The Team organized a meeting in September at JSC with the special education task leader, JSC and Krug (contractor) researchers, a biomedical advisor, the TU Office and the Team. The meeting participants developed ideas for applying the technologies; a meeting with a potential corporate partner is scheduled in November. (p. 31, 103)

- The RTI Applications Team supported **Stennis Space Center** in developing a new Applications Engineering Project to build a novel **containment structure for lead paint residue** removed from bridges, water towers, and other steel structures. The Applications Team also participated in meetings with the U.S. Occupational Safety and Health Administration and Steel Structures Painting Council seminar on Lead Paint Removal from Industrial Structures. (p. 66)
- RTI participated in meetings with the Technology Utilization Office at the **NASA Marshall Space Flight Center** and a video teleconference with NASA HQ on February 19. Mr. Ray Gilbert from NASA Code C and representatives from Gallaudet University talked from Washington, D.C. with a MSFC team including NASA engineers, the MSFC TU Office, and Applied Research, Inc., Huntsville, AL. The project titled "**Emergency Vehicle Alert System**" is being reactivated with this team, to allow hearing impaired drivers to be alerted to the presence of police, fire, ambulance and other emergency vehicles.
- The Team worked with **NASA HQ**, and with the TU office and technical experts at JSC to obtain a funding commitment to the project titled "**Visual Identification and Processing of Eye Responses (VIPER)**." The proposed system will allow rapid and simultaneous identification of a person and any drug use by that person and is of particular interest to parole offices.
- A series of teleconferences were held by the Team, Mr. Ray Gilbert from Code CU – NASA Headquarters, the **National Institute of Corrections, the Office for National Drug Control Policy, the U.S. Customs Service, Jet Propulsion Laboratory, and Quantum Magnetics, Inc.** The conferences were an attempt to establish a coordinated funding and technical research approach to solving the contraband detection problems of interest to all the organizations. This potentially important applications project is still in the early feasibility stages. A detailed review and Project Plan has been prepared by Dr. Stanley Mannett of JPL. (p. 140)
- The Applications Team met with Mr. Kevin Jackson, representing the **National Institute of Corrections**, on August 29 at RTI offices. The current status of potential technology transfers to corrections was discussed, along with new concepts. Emphasis is currently being placed on using NASA fault tolerance techniques for perimeter security and on improved communications and remote sensing for electronic monitoring.
- The **Reconfigurable Modular Manipulator System (RMMS)** commercialization meeting was held at GSFC in November. The participants from NASA, DOE, and Carnegie Mellon University agreed on a strategy for commercializing the robotic system. The Team then contacted engineers and managers in government, utilities, hazardous waste, flexible manufacturing, robotic manipulator

SECTION 2.0: HIGHLIGHTS

manufacturers, automated systems, and other related industries to promote the RMMS. Interested industry representatives received the **RMMS Prospectus** developed by the Team. (p. 75)

- The Team responded to an inquiry from Bill Parker of Light Age Tech Labs, Inc. in Vermont concerning **artificial aurora generation**. Light Age is completing a feasibility study for several major museums to develop an artificial aurora display for museum display and educational purposes. In August, the Team arranged a meeting at Marshall Space Flight Center with Dr. Tom Moore, Chief, Magnetospheric Physics Branch and the TU Office. The group reached an agreement for informal exchanges between Mr. Parker and Dr. Moore; when the discussion leads to the need for more significant resources, the group has agreed to draft a formal agreement. (p. 108)
- With Mr. Ray Gilbert of NASA Headquarters, we held a detailed teleconference with Dr. Taylor Wang, Vanderbilt University, on progress and planning for the **Cell Encapsulation** project. Dr. Wang and the team have met with researchers at the University of Toronto, venture capitalists from Boston and a law firm to plan further R&D and ultimate marketing. The technical status established that live cell testing would begin in about 18 months. Some related successes have been achieved at the Islet Cell Transplant Institute at UCLA. An annual report from the Vanderbilt researchers was delivered to the Applications Team. (p. 150)
- **Marshall Space Flight Center** has initiated an informal project, in response to a RTI problem statement, to look at the feasibility of developing an **improved suspension system for wheelchairs**. Such a system will not only yield a more comfortable ride, but also allow easier operation over irregular terrain. As concepts are developed, RTI will help evaluate these along with the problem originators at the **National Easter Seal Society**. (p. 160)
- The Team obtained input from six representatives from different industrial areas to prepare an information brochure on the **Convolver for Real-time Image and Signal Processing (CRISP)** technology developed at NASA Langley Research Center. In addition to providing technology information, the brochure discusses a commercialization workshop for the CRISP. The Team will coordinate industry responses (via a return postcard) from the brochure and assist LaRC in conducting the workshop, currently scheduled for February 1992. The CRISP technology represents a real-time processing algorithm to remove noise and artifacts in ultrasonic, microwave, and other signal processing systems in such applications as radar, electronic instrumentation equipment, and aircraft inspection. (p. 114)

- The Team developed a prospectus for the **Capaciflector capacitive skin sensor** being developed at **Goddard Space Flight Center**. The Capaciflector Prospectus details the technology, current practice, market potential, and current status of the Capaciflector. The Prospectus provides a mechanism to distribute information of interest to relevant corporations. The Prospectus was distributed to potential industrial partners; two groups of companies responded, requesting to participate. The Team is currently working with the Joint Sponsored Research Program in a TU collaborative commercialization effort. (p. 64)
- RTI is assisting MSFC in developing a strategy to secure co-funding for the **Water Window X-Ray Microscope** project. Both the National Institutes of Health and the National Science Foundation have expressed interest, but their constraint to normal grant procedures for funding causes a problem in that MSFC wishes to remain in the project leader role (rather than a university that would submit the grant application). We have also reviewed a five year business plan by a company, Opti-Scan Technologies, Inc. that has been formed to commercialize the x-ray microscope. RTI met with the project leader and the TU Office at MSFC in July to develop a complete strategy for seeking co-funding and for managing commercialization aspects of the project. (p. 63)
- Because of the considerable interest generated by the RTI Team's problem statement on applying NASA technology to **Kuwaiti oil fires**, Dr. Cleland prepared a package of information and contacts for several of the interested parties who had provided concepts. Organizations who have received packages include G&L Engineering, Washington, DC; Marshall Space Flight Center; Microcraft, Inc., Huntsville, AL; Rust Engineering, Birmingham, AL; O'Brien, Gowens and Simpson, Inc., Midland, TX; Inferno Snuffers, San Antonio, TX; and Greer Associates, Huntsville, AL. (p. 72)

An associated technology transfer opportunity for **detection of subsurface and underwater land mines** in the Kuwaiti coastal region was also investigated by the team. Synthetic aperture radar (Stennis Space Center) and Lidar (Goddard Space Flight Center) were examined as technology transfer possibilities. Lidar has demonstrated small object detection at water depths of 10 meters and appears to be an excellent option for mine detection. A company (40 West Project Management, Inc., Fullerton, California) is pursuing contacts with the Kuwaiti government in an attempt to access cost sharing funds for an applications project. (p. 119)

- The Applications Team has reviewed a new opportunity for NASA technology transfer through the **Industrial Innovation Laboratory, Kansas Augmented Telerobotics (KAT) and Computed Integrated Manufacturing (CIM) at the University of Kansas**. Allied Signal, Inc. is interested in telerobotics technology

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for handling of carcinogens and in CIM cells for automatic fixturing applications. Opportunities with Hurco Machine Tools, Boeing Aircraft and VeKtec Corporation are also being pursued.

- RTI delivered a final report titled **"Flight Telerobotic Servicer (FTS) Commercial Applications of FTS Technology"** to Martin Marietta Corporation Astronautics Group, Denver, Colorado. This technology transfer project was supported by the FTS program and by the Goddard Space Flight Center Technology Utilization Office. Excellent opportunities for NASA-sponsored FTS technology to the **U.S. coal mining industry** have been identified and are detailed in the report. The report also summarizes a number of other potential opportunities for transfer of NASA-sponsored telerobotics technology. (p. 86, 96)
- Interest has increased from several areas of industry in NASA spinoffs from the **Space Shuttles tiles** and Space Plane thermal insulation activities. For example, the Team responded to a request by Harris Systems for new ceramic materials for firescreen doors. The Team has also promoted NASA solutions to high-temperature insulation problems to Tribological Industries (Dearborn, MI), Aeroquip Corporation (Zan Wert, OH), FOSTEC Inc. (Auburn, NY), Texas Components (Houston, TX), and Allied Signal (Richmond, VA).
- Stephen Lehrman assisted Ann Johnson and Rick Galle of **Stennis Space Center** in contacting Oscar Cabra of EPA Region VI regarding meeting to discuss EPA and NASA collaboration on a design manual for **aquatic plant filter systems**.
- Discussions have been held with Dr. David Bubenheim, Ames Research Center, on the possible role of NASA Code C involvement with establishing a NASA life sciences facility at an abandoned government building complex near Modesto, California. Ray Gilbert from NASA Headquarters and the Applications Team will follow through and examine the possibilities of expanding the current technology transfer project with **Environmental Growth Chambers**. (p. 157)

Assistance to NASA Centers and Headquarters

- RTI met on two occasions with a task force established by NASA Headquarters to develop a methodology to study the **spinoff benefits** from application engineering projects as well as to develop a model for successful projects. Using input from the Centers and from RTI records, RTI created a database of all applications projects. The task force decided to study those projects ending between 1980-1987. RTI has developed a separate database of these projects and developed a prioritized list of projects for benefits data collection.
- At the request of the **Lewis Research Center** TU Office, the Team assessed the **commercial opportunities for two new polyimide materials**, VCAP and PMR-II-50. The Team prepared a written report identifying a market for these materials in printed circuit boards, flue gas filters, and high temperature adhesives. The Team contacted American Cyanamid's Adhesives Division and re-initiated discussions between the Lewis Research Center Polymer Branch and American Cyanamid regarding a Space Act Agreement.
- At the request of **Langley Research Center**, RTI worked with Clemson University and Smith-Nephew Richards, Inc. to assess the feasibility of using **inductive heating in the production of composite orthopedic implants**. Both a short term application (of immediate interest to Richards) and long term applications were identified. LaRC initiated a low-key effort to start a project.
- RTI assisted MSFC in the Portable Powered Seat Lift project by identifying organizations to develop prototypes.
- The Team assisted **NASA HQ** in drafting a set of criteria to be met in selecting Applications Engineering Projects. These criteria, based on past Applications Engineering Project experience, and other technology transfer programs, provide a straightforward mechanism for determining the extent to which the aspects of Applications Engineering Projects from definition to co-funding are present. This provides the Center with information to assist them in selecting Applications Engineering Projects with the greatest potential for success.
- Joe Mathis, Frank Farmer, and Greg Manuel of the **Langley Research Center** TU Office visited RTI to discuss the LaRC TU program and current areas where the Applications Team can assist them in developing projects or in commercializing results of current projects.
- At the request of Mr. Len Ault, **NASA HQ**, the RTI Applications Team developed a list of NASA technology that could be used in manufacturing. This information was provided by Mr. Ault to Mr. James Bain, Code AD, and ultimately to Mr. J.R.

SECTION 2.0: HIGHLIGHTS

Thompson for inclusion in NASA information to the Federal Coordinating Committee on Science and Technology.

- New opportunities for Team assistance to the **Martin Marietta Michoud** technology transfer office are being pursued in the areas of automated manufacturing cell control and in innovative robot gripper design. Participating companies are being sought in coordination with the **NASA MSFC TU Office**.
- The Applications Team has supported NASA Headquarters Code C and the NASA Langley Technology Utilization office in reviewing a new proposal by Arnold Systems for follow-on testing of the **Oscillating Cascade** previously tested at the LaRC wind tunnel in 1990. Revisions have been made to the proposal suggesting a more limited scope of work and consultant participation by Rensselaer Polytechnic Institute in New York.
- RTI has provided assistance to **NASA Headquarters Life Sciences** and to the **KSC Biomedical Engineering Office** in identifying possible presenters for sessions on aerospace bioengineering at the **1991 IEEE Engineering in Medicine and Biology Society meeting**, early November in Orlando.
- At the request of Ray Gilbert, RTI represented NASA at a meeting of the **Interagency Committee for Disability Research**. Dr. Doris Rouse made a presentation on the NASA TU program's activities in rehabilitation.

3.0 MAJOR INITIATIVES

A fundamental objective of the RTI Team is to maximize the impact of NASA's Applications Engineering Program resources on the competitiveness of U.S. industry. To accomplish this objective, there are two central components in our technical approach.

- Identify and work with industries that meet the following criteria:
 - are struggling to compete globally
 - would benefit from the infusion of new technologies
 - can be expected to be receptive to acquiring NASA technology.
- Leverage NASA resources by working with organizations in the public and private sectors that may provide the following resources:
 - an efficient mechanism for identifying priority problem areas whose solution would benefit an entire industry sector
 - cofunding for projects addressing the selected problem areas. These organizations include industry associations, professional societies, industry consortia, national user groups and federal agencies.

This Major Initiatives section summarizes the progress we have made over the past year in several initiatives with organizations representing the needs of specific industry sectors or user groups. These summaries focus on the processes utilized to identify and pursue priority problems and serve as instructive models of our technology transfer methodology.

NATIONAL CENTER FOR MANUFACTURING SCIENCES

RTI Team Personnel: Stephen A. Lehrman

Introduction

The National Center for Manufacturing Sciences (NCMS), Inc. is a consortium of more than 120 U.S. companies committed to making U.S. manufacturing globally competitive. Their members include large corporations such as General Motors, AT&T, and Digital Equipment Corporation as well as small companies such as Remmele Engineering. NCMS's charter is to assist U.S. companies working in discrete part manufacturing with particular emphasis on the automotive, aerospace, and electronics industries. NCMS is particularly interested in using government sponsored research and development to solve specific technology related problems in manufacturing.

Process

In December 1990, RTI initiated discussion with Dr. Richard Macon and Dr. Don Walukas of NCMS regarding a visit by the NASA Technology Applications Team. The purpose of the visit was to explain the NASA Technology Utilization Program and to discuss areas for mutual cooperation between NCMS and NASA.

Tony Ratajczak and Stephen Lehrman visited NCMS in Ann Arbor, MI in January 1991. RTI gave an overview of the TU Program and Tony Ratajczak discussed the Lewis Research Center program. The meeting was very productive and both parties realized that there were indeed areas of mutual interest. It was agreed to develop a Memorandum of Understanding (MOU) between NCMS and NASA and to hold problem identification workshops on specific technologies.

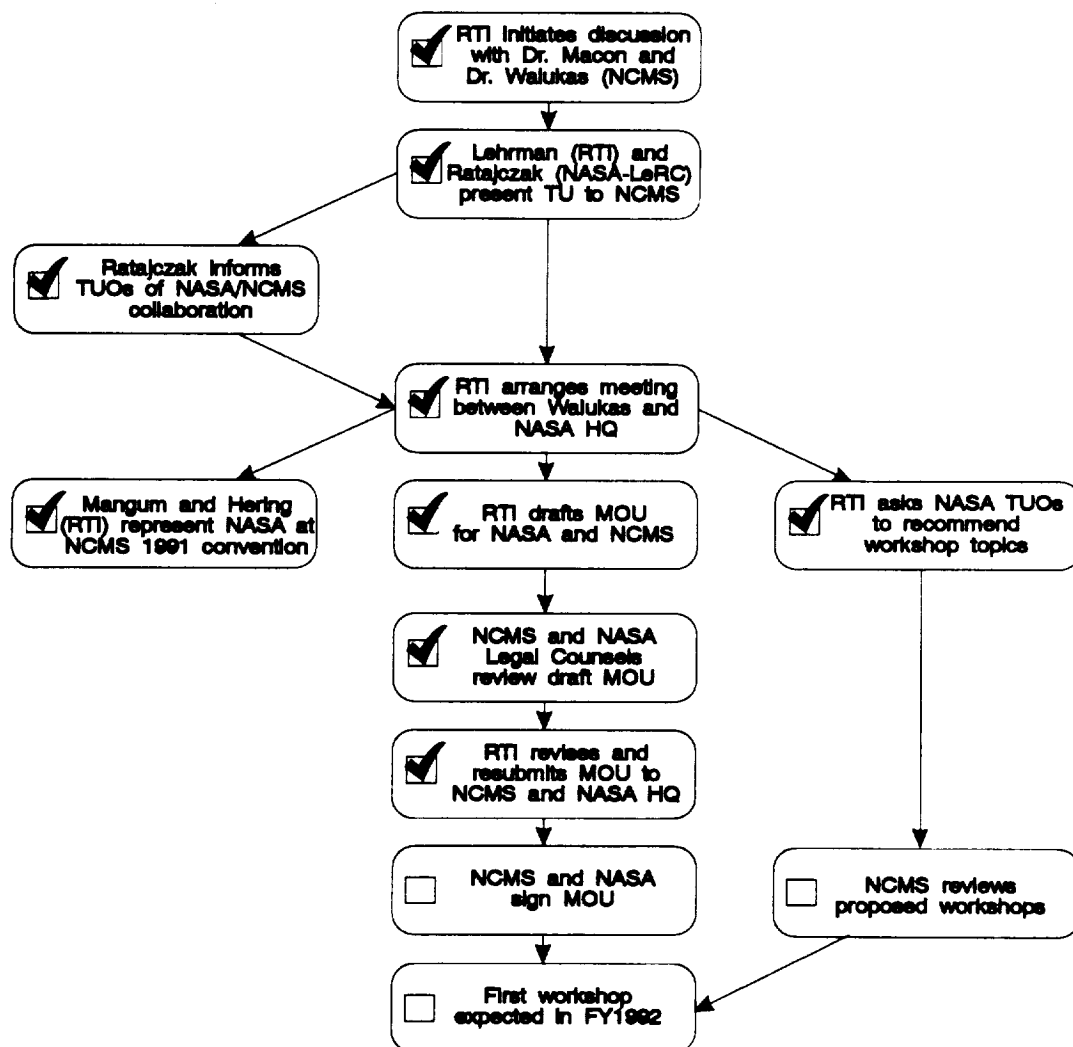
At the January 1991 Technology Utilization Officers Meeting, Tony Ratajczak discussed the meeting with NCMS. Mr. Ratajczak explained that each TUO would be asked to recommend technologies at their Field Center for the workshops.

RTI arranged a meeting for Dr. Walukas with Frank Penaranda, Ray Gilbert, and Tony Ratajczak in Washington in February 1991. The objectives of this meeting were to present NCMS to NASA Headquarters, decide whether or not to have workshops, and decide whether or not to proceed with a Memorandum of Understanding. At the conclusion of the meeting, NASA instructed RTI to proceed with both the workshops and the MOU.

In March 1991, RTI sent a letter to each TUO inviting them to submit topics for the workshops. Responses were received from Marshall, Lewis, Goddard, and Kennedy. These responses were forwarded to NCMS for their review.

Simultaneously, RTI began working on a Draft MOU. The Draft MOU was reviewed by NCMS' legal counsel and then sent to NASA Headquarters. NASA's Office of the General Counsel reviewed the Draft MOU and provided their comments through Code C back to RTI. RTI incorporated Code G's comments into a revised draft and resubmitted the MOU to NASA Headquarters in September 1991.

As another way of informing their members about the NASA TU Program, NCMS asked RTI to represent NASA at the NCMS 1991 Annual Meeting of Members in Dallas in May 1991. Dean Hering and Steve Mangum of RTI attended the meeting and discussed the NASA TU Program with a number of the attendees. (See diagram below)



SECTION 3.0: MAJOR INITIATIVES

Results

The recommendations for problem identification workshops are being reviewed by NCMS. This review is taking place with the NCMS member companies. A recommendation for the first workshop is expected by the beginning of next year.

The revised draft Memorandum of Understanding has been reviewed by the Technology Utilization Division and forwarded to the Office of the General Counsel for their approval. The MOU calls for the following:

- Information exchange in agreed-upon areas of cooperation;
- Technical workshops which shall provide the basis for continuing identification of opportunities for the transfer of NASA technologies to the U.S. manufacturing industry;
- Collaborative Applications Engineering Projects to adapt NASA developed technology for use by the U.S. manufacturing industry.

Plans

We anticipate organizing one problem identification workshop during the first half of Fiscal Year 1992. This workshop will be used to define priority manufacturing problems and identify applicable NASA technology to solve the need. The revised draft Memorandum of Understanding is in its final review. We expect that the MOU will be acceptable to both NASA and NCMS with minor changes. Once the MOU is signed, we will work with NCMS to develop technology transfer opportunities.

NASA/U.S. CONFERENCE OF MAYORS TECHNOLOGY TRANSFER INITIATIVE

RTI Team Personnel: Stephen D. Mangum, Doris J. Rouse

Introduction

Major cities in our Nation spend billions of dollars each year to provide and expand basic services to the public. Each city worries about funding schools, jails, and facilities for the aging and homeless as well as potholes, collapsing bridges, leaking water mains, stormwater-caused sewer overflows, traffic gridlock, new landfills, or expanding the airport, and a host of other factors. The Office of Technology Assessment estimates that Federal, State, and local governments currently spend about \$140 billion annually on building, operating, and maintaining public works facilities (local governments alone are responsible for over 70 percent of these facilities).¹

Realizing the scope of the problems faced by our Nation's cities, the Technology Applications Team contacted the U.S. Conference of Mayors (USCM). The principal roles of the USCM are to aid the development of effective national urban policy, to serve as a legislative action force in strengthening federal-city relationships, to ensure that federal policy meets urban needs, and to provide Mayors with leadership and management tools of value in their cities. The USCM works with cities with a population over 30,000 -- there are about 950 such cities in the country today. As a part of their overall mission, the USCM initiated a national effort to promote technology transfer from federal laboratories and universities to cities. This initiative was initially funded by the U.S. Economic Development Administration; at present, it is funded by the Federal Laboratory Consortium. The Team believes the USCM is an excellent, nationally-oriented organization to help identify priority technical needs within select U.S. cities. The USCM and NASA have agreed to cooperate in a special initiative to match NASA aerospace technology to solve priority problems in select U.S. cities.

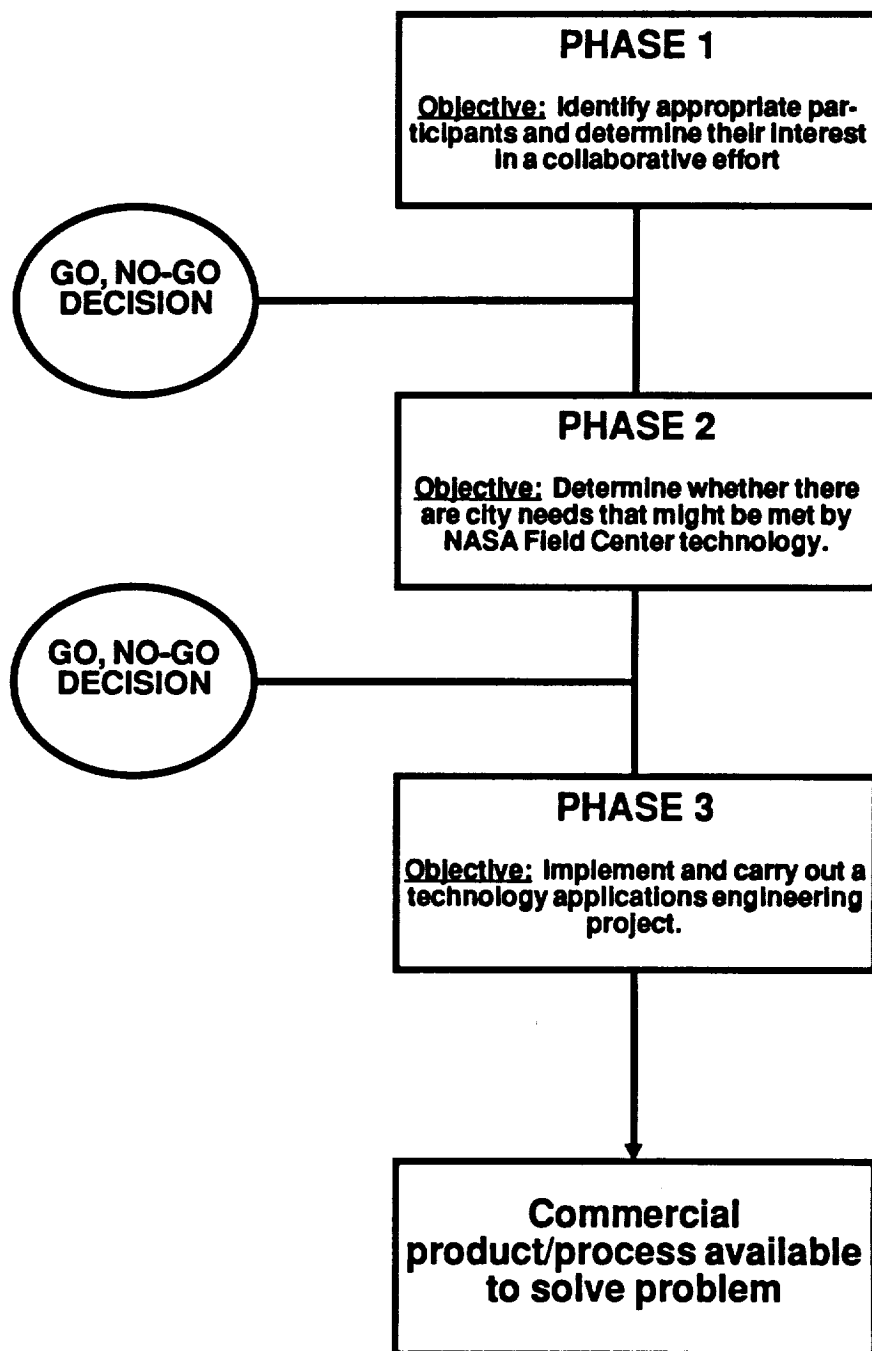
Process

Stephen Mangum and Doris Rouse of RTI met with Dr. Kay Scrimger (Director, Office of Program Development and Technical Assistance, USCM) to develop a plan to pursue this initiative. A three-phased approach was

SECTION 3.0: MAJOR INITIATIVES

developed with objectives and go, no-go decision points set for each phase (see diagram below). The plan was then reviewed and approved by TU officials at NASA Headquarters.

USCM / NASA TECHNOLOGY TRANSFER INITIATIVE: A PHASED APPROACH



Results

RTI, USCM, and appropriate NASA Field Center TUOs have met with officials from the cities of Knoxville, TN and Houston, TX. The following summarizes the progress with each city:

KNOXVILLE

HOUSTON

P H A S E 1	<input checked="" type="checkbox"/> USCM selects Knoxville to participate – March 1991	<input checked="" type="checkbox"/> USCM selects Houston to participate – March 1991
	<input checked="" type="checkbox"/> USCM determines interest of Mayor	<input checked="" type="checkbox"/> RTI contacts JSC TUO to determine interest
	<input checked="" type="checkbox"/> RTI contacts MSFC TUO to determine interest – March 1991	<input checked="" type="checkbox"/> Houston Mayor contacts JSC Center Director (Cohen) – April 1991
	<input checked="" type="checkbox"/> Decision made to proceed to Phase 2	<input checked="" type="checkbox"/> Decision made to proceed to Phase 2
P H A S E 2	<input checked="" type="checkbox"/> RTI, MSFC TUO, City Staff, and USCM meet to discuss problem areas, roles of participants, approach, etc.	<input checked="" type="checkbox"/> RTI, JSC TUO, City Staff, and USCM meet to discuss problem areas, roles of participants, approach, etc.
	<input checked="" type="checkbox"/> City Staff forwards brief problem summaries to RTI Team & MSFC	<input checked="" type="checkbox"/> City Staff forwards brief problem summaries to RTI Team & MSFC
	<input checked="" type="checkbox"/> RTI & MSFC review problem summaries and respond.	<input checked="" type="checkbox"/> RTI & JSC review problem summaries and respond.
	<input type="checkbox"/> City Staff prioritizes problems	<input type="checkbox"/> City Staff prioritizes problems
	<input type="checkbox"/> All parties meet to discuss project possibilities	<input type="checkbox"/> All parties meet to discuss project possibilities
P H A S E 3	<input type="checkbox"/> RTI arranges meeting with all participants to develop project plan with technical and fiscal responsibilities	<input type="checkbox"/> RTI arranges meeting with all participants to develop project plan with technical and fiscal responsibilities
	<input type="checkbox"/> NASA/Knoxville seek co-funding opportunities	<input type="checkbox"/> NASA/Houston seek co-funding opportunities
	<input type="checkbox"/> NASA/Knoxville seek commercial partner	<input type="checkbox"/> NASA/Houston seek commercial partner

Plans

As shown in the diagram on the previous page, RTI plans to meet with Knoxville and Houston officials early in the next year to select problems that have the highest probability to be matched with NASA technology. Also, discussions regarding a project plan establishing technical and fiscal responsibilities of participating organizations will take place at that meeting. After a project plan has been agreed upon, RTI will support each city and the participating NASA Field Center TUO in carrying out the project through the commercialization stage.

Reference

- ¹ U.S. Congress, Office of Technology Assessment, *Delivering the Goods: Public Works Technologies, Management, and Financing*, OTA-SET-477 (Washington, DC: U.S. Government Printing Office, April 1991), p. 3.

CIVIL ENGINEERING RESEARCH FOUNDATION

RTI Team Personnel: Stephen A. Lehrman

Introduction:

The Civil Engineering Research Foundation (CERF) was created by the American Society of Civil Engineers out of the need to establish a coordinated and directed research and technology transfer effort addressing the needs of the civil engineering profession on an industry-wide basis. CERF began operation on May 1, 1989.

A major element of CERF's near term mission is to establish a National Civil Engineering Research Agenda which can be used by government, academia, and the private sector. CERF, in conjunction with several government agencies and private organizations, conducted a National Civil Engineering Research Needs Forum on January 28-30, 1991 in Washington, DC. The purpose of the Forum was to identify, assess, and prioritize the national research needs for the civil engineering profession.

One of the five Thrust Areas of the Forum was Commercialization of Research Results/Technology Transfer. The NASA Technology Applications Team was invited to participate in the panel for this Thrust Area.

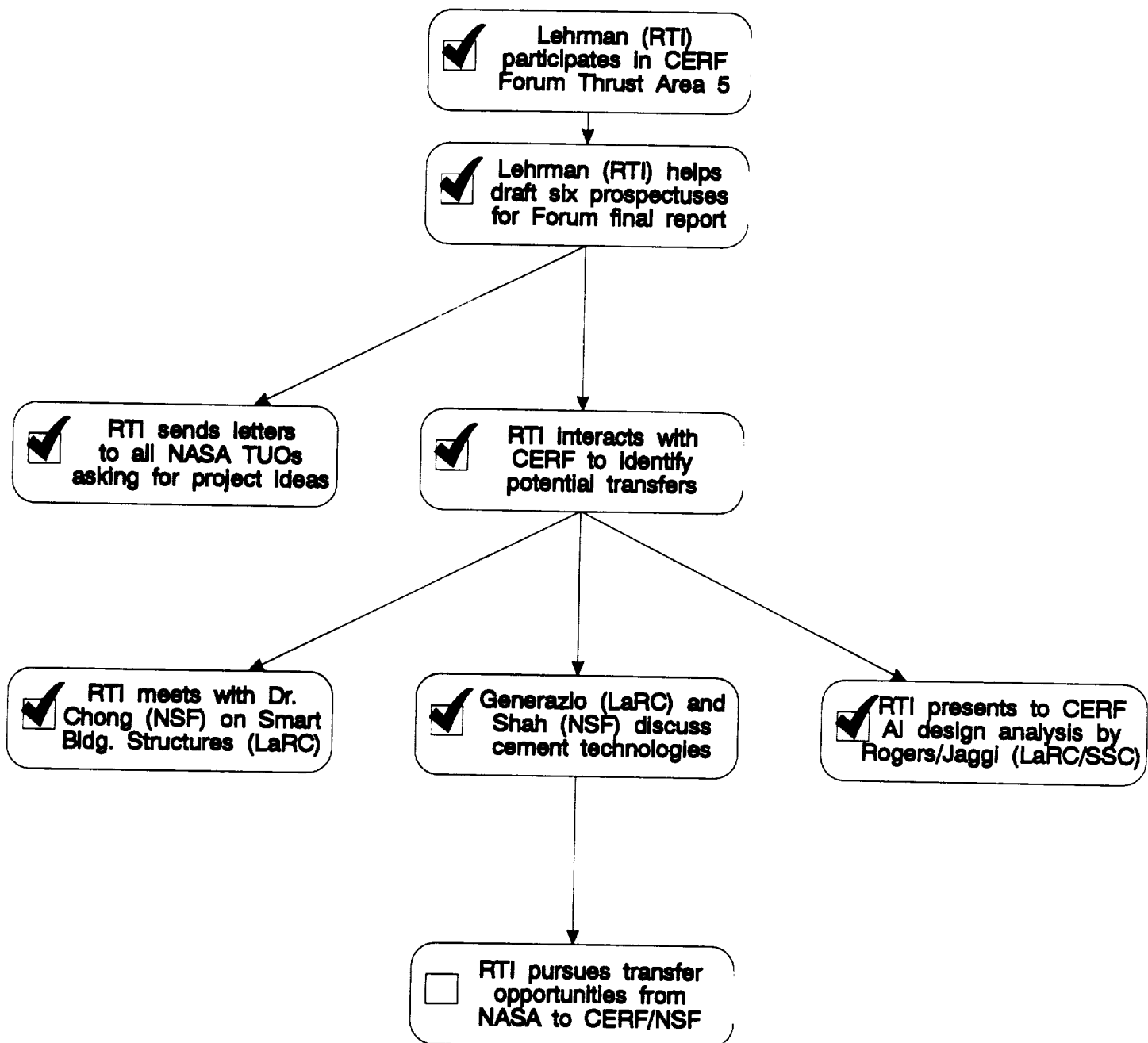
Process:

Stephen Lehrman of RTI participated in the CERF Forum Thrust Area 5 on commercialization and technology transfer. At this meeting, he was able to discuss industry-wide problems with individuals from construction companies, national associations, universities, national laboratories, and federal agencies. He participated in drafting six research prospectuses for the Forum final report. The civil engineering profession, and especially the construction industry, is interested in applications of advanced composite materials, nondestructive examination techniques, and automation and robotics. These are all areas of NASA expertise.

Following the Forum, RTI initiated a task to define some of these industry-wide problems and identify civil engineering-related NASA technology. A letter was sent to the Technology Utilization Officer at each Field Center requesting their assistance in identifying civil engineering, construction, design, infrastructure revitalization, environmental management, or a non-civil engineering technology that would be of use to the civil engineering profession. The Marshall TU Office published this request in the Marshall Star.

SECTION 3.0: MAJOR INITIATIVES

RTI continues to interact with CERF to identify applications for NASA technology. These interactions include telephone calls, exchanges of information, and participation in CERF technology transfer activities.



Results:

A number of fruitful discussions between NASA researchers and scientists and civil engineering professionals have taken place. These discussions are preliminary but may lead to the development of technology transfer opportunities.

Dr. Ed Generazio of Lewis Research Center, temporarily on loan to the Langley Research Center Nondestructive Measurement Sciences Branch, has been involved in the development of instrumentation for ultrasonic imaging of ceramic microstructure. Dr. Surendra Shah, Director of the NSF Center for Advanced Cement-Based Materials at Northwestern University, has expressed interest in using this instrumentation to better characterize cement and concrete microstructure. Dr. Generazio and Dr. Shah have exchanged technical publications.

RTI met with Dr. Ken Chong of the National Science Foundation to discuss NSF's new initiative on Intelligent Building Structures. Dr. Chong has spoken with Dr. Joseph Heyman of Langley Research Center regarding the adaptation of NASA technology for construction.

RTI has also spoken with Mr. James Rogers of Langley Research Center and Dr. S. Jaggi of Stennis Space Center. Mr. Rogers has developed an artificial intelligence computer program for analyzing complex designs such as the High Speed Civil Transport Airplane. RTI believes that this analysis tool could be used on the design of unique civil engineering projects such as the Superconducting Supercollider and Magnetic Levitation Train systems. Dr. Jaggi has developed a PC based realtime monitoring system for cable stayed bridges. Both of these technologies were presented by RTI to CERF for their information.

Plans:

RTI plans to continue to work with Dr. Generazio and Dr. Heyman to identify opportunities for transferring NASA technology to civil engineering. Our immediate plans are to arrange by the end of the year a telephone conference call between Dr. Generazio and Dr. Shah to discuss areas of mutual collaboration.

DIAGNOSTIC IMAGING INITIATIVE WITH THE NATIONAL CANCER INSTITUTE

RTI Team Personnel: Daniel L. Winfield

Introduction

Diagnostic imaging is an important tool in the early detection and treatment of many forms of cancer. The past two decades have seen the emergence of several new diagnostic imaging modalities; today's requirements focus on how to use these modalities more effectively and how to extract more information from the available images. Across these various imaging methods there is a universal need for more powerful, yet economic, digital signal acquisition, processing and display technologies. Automated image registration and classification, automated decision making, and multiparameter tissue characterization are additional areas for technology development. NASA has excelled in many of these areas of image acquisition, processing, storage and display. RTI analysis indicated that NASA could make important technology contributions to allow continuing advancements in this field. RTI provided input to a recent article in the Journal of the National Cancer Institute (July 17, 1991) which highlighted examples of past and current applications of space technology to oncology.

Accordingly, the RTI Team has initiated several efforts with the National Cancer Institute. We chose to work with the Diagnostic Imaging Research Branch (DIRB) which is the leading organization in the National Cancer Institute to enhance research support in medical imaging and related new technologies. The important aspects of the DIRB mission are the dissemination of information, education, and identification of new important directions in technology development and technology transfer. Through preliminary interactions we have stimulated interest on the part of NCI to enhance interactions with other Federal agencies supporting technology developments that can be successfully applied to medical imaging research.

Results

Initially, RTI arranged for NASA professionals to participate in a meeting with a NCI-supported Cooperative Working Group on Radiation Treatment Planning. Two problem statements were developed by RTI from this meeting. One response from Stennis Space Center met with interest, and RTI arranged for SSC scientists to visit NCI; a feasibility project has been proposed. In follow-up to this Working Group interaction, NCI invited Charles Gott and James Villareal

of the Johnson Space Center to make a presentation on artificial intelligence and computer graphics to a NCI workshop on "3D Data Display and Analysis for Cancer Treatment Planning". Also at the request of NCI, Dan Winfield of RTI and Dr. Paul Schenker of the Jet Propulsion Laboratory gave presentations to an NCI workshop on "Imaging-Guided Stereotactic Tumor Diagnosis and Treatment" and introduced the areas of telerobotics and man-machine systems.

Process

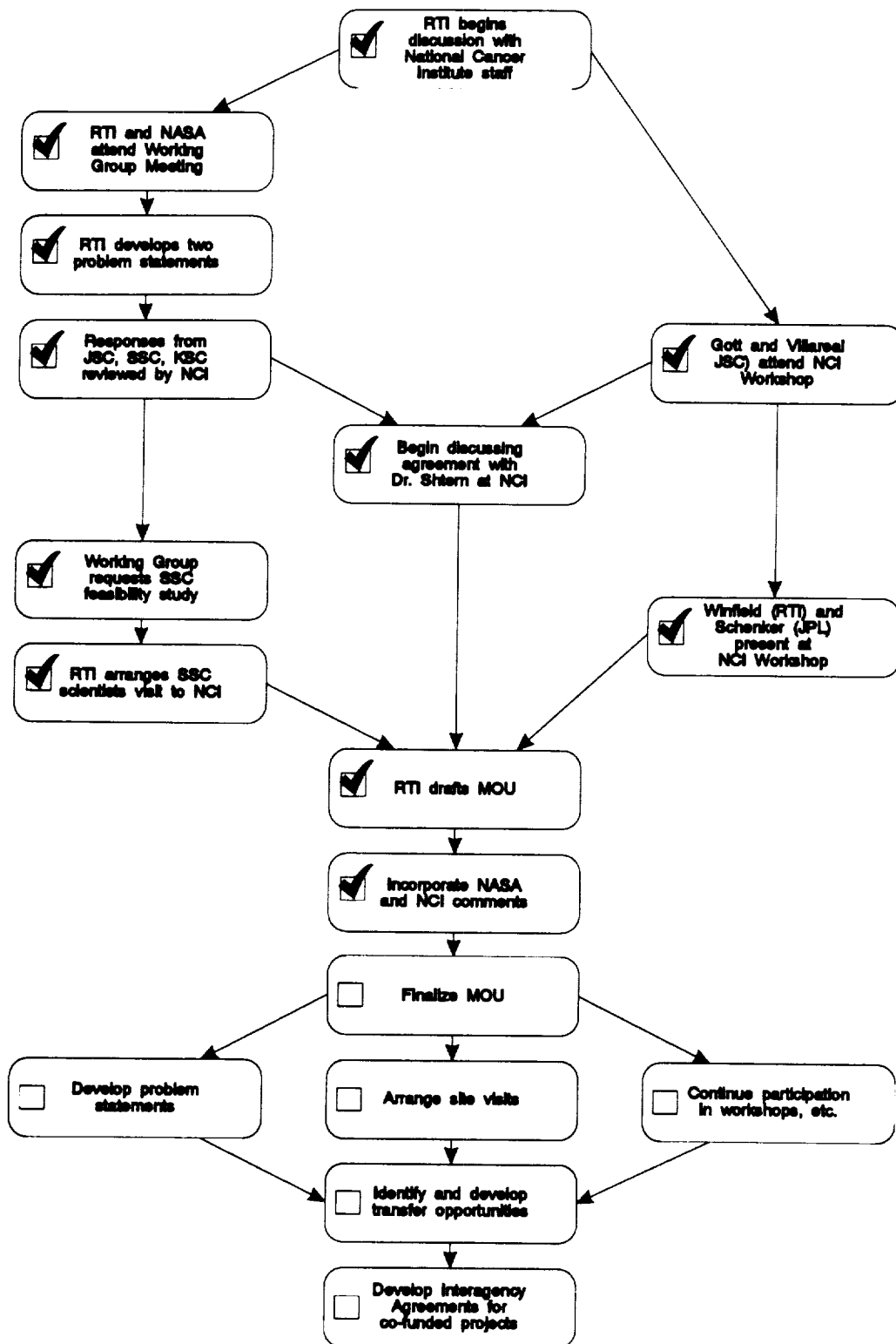
These preliminary discussions have made it clear that enhanced interactions between DIRB and NASA will facilitate other areas of imaging research. RTI has since worked with NCI and NASA to draft an Agreement which sets forth a plan to go beyond these preliminary interactions to seek out and support opportunities to adapt aerospace technology to solve important problems in medical imaging for cancer detection and treatment. Several approaches will be utilized to identify opportunities:

- 1) The RTI Applications Team will work with DIRB to define specific problems or technology needs in diagnostic imaging. NASA will respond to these problem statements with concepts/ideas based upon NASA technology and expertise. DIRB and its funded researchers will evaluate proposed concepts for technical feasibility, competitive advantage/disadvantage, potential impact, etc.
- 2) Both NCI and NASA currently support workshops and conferences in specific technical areas. The parties will use these workshops as avenues for technical information exchange between the disciplines.
- 3) NASA and NCI may arrange site visits for the purpose of cross-fertilization of ideas, needs, and capabilities.

Plans

This Agreement is now in final review at NASA HQ and NCI. We anticipate developing several problem statements with NCI and will work to arrange appropriate participation by NASA at selected NCI workshops and vice versa. Any of the above three steps may lead to technology transfer opportunities. Upon positive review of these opportunities by NCI and NASA, RTI will assist the participants in developing projects to be co-funded by NCI and NASA. Follow-on agreements will be written around these specific project plans.

SECTION 3.0: MAJOR INITIATIVES



SPECIAL EDUCATION TECHNOLOGY INITIATIVE

RTI Team Personnel: Dean Hering, Steve Lehrman

Introduction

Forty-five million Americans suffer from disabilities. Over twelve million of these are working age Americans who are limited or prevented from working because of their disability; the resulting cost to society is \$300 billion per year. A substantial portion of the cost could be reduced by improving education for people with disabilities so that they can contribute to the nation's work force and improve their quality of life. Realizing that emerging technologies play a key role in enabling students to receive education, RTI initiated contact with the Center for Special Education Technology, a center funded by the U.S. Department of Education to assess and locate technology that will assist disabled students. This Initiative's purpose: define problems faced by special education students that might be solved via the application of NASA technology and team NASA with manufacturers to implement the solutions.

Process

RTI met with the Director of the Center for Special Education Technology and discussed the TU program. The Center formed an expert panel of ten education practitioners from across the country to define problem areas that might benefit from NASA technology. The Team and the panel held a teleconference in October 1990 and identified sixteen initial problems for the Team to review.

The Team reviewed the problem areas, identified commercially available technology that might meet several problem requirements, located NASA technology and personnel that might meet several of the others, and ranked the problem areas in the order most likely to be good matches with NASA technology. The Team developed a set of focus questions for the panel which were used as the basis for a second teleconference in December 1990. During this conference the expert panel specified the priority problem areas: monitoring and life support of medically fragile children in the educational setting and intelligent computer aided training (ICAT). The group assigned panel members to develop the areas with assistance from the Team. The panel also set up a special session at the 1991 International Conference on Special Education Technology, co-chaired by RTI.

SECTION 3.0: MAJOR INITIATIVES

At the conference the Team met with industry representatives to insure active industry participation in the session. During the special session, meeting participants broke into working groups, developed the problem areas, and assigned problem statement leaders.

Special Education Technology Initiative

Initiative Activity	Team Contribution
October 1990 <i>Teleconference</i> Special Education Expert Panel identifies 16 problem areas	Introduces TU Program Provides guidance for types of problems and specifying problems for NASA
November 1990 Research Problem Areas	Discusses problems with industry Locates commercial/existing technology Defines criteria for evaluating and prioritizing problem areas
December 1990 <i>Teleconference</i> Review and prioritize problem areas	Guides panelists in reviewing problem areas and identifying priority problems. Assists in defining technical specifications of problem areas
January 1991 <i>Special Session at International Conference on Special Education Technology</i> Industry and other special education experts join panel, form working groups, and develop problem areas.	Involves industry in session Co-chairs session Specifies criteria and examples for problem statements Provides guidance to working groups on technically specifying problems Discusses possible co-funding sources with special education experts
February-April 1991 Develop Medically Fragile Children Problem Statement	Assists in translating student needs into technical requirements Incorporates industry needs in problem statement Researches federal legislation to include in problem statement Assists in defining impact of solution
May-August 1991 Identify NASA Technology	Locates and recommends NASA researchers and technology Submits problem statement/recommendations to Field Centers Evaluates responses with problem area leader Discusses match with TU Office and NASA Program managers
September 1991 <i>Meeting at JSC</i> Assess Applicability of technologies	Organizes meeting Locates industry/clinical advisor to evaluate applicability Assists researchers in developing presentation for meeting Focuses group on problem and discussion on how technologies would be applied Assists group in determining criteria for corporate partner
November 1991 <i>Meeting with Office of Special Education Programs</i> Identify Federal funding programs to leverage NASA funding	Uses RTI and Special Education Contacts to locate potential federal funding sources Contacts program directors, sends background material, sets up meeting for early November
November 1991 <i>Meeting at JSC</i> Discuss possible collaboration with potential corporate partner	Contacts potential corporate partner Researches company background, products, and financial status Briefs V.P. of Advanced Product Development Organizes Meeting

RTI worked with these leaders in developing the problem statements. The intelligent computer assisted training problem statement leader is currently working to define the technical specifications. The RTI Team assisted the medically fragile children problem statement leader in specifying technical requirements and contacted manufacturers to incorporate industry input into the problem statement, which seeks technologies to assist special education students who require multiple monitoring and life support systems. RTI also researched new federal legislation, requiring that such students be allowed access to public schools, to include in the impact portion of the problem statement.

The Team located several promising technologies and researchers at NASA field centers. Two such groups responded from Johnson Space Center. The Team discussed the technologies with the researchers and the special education panel and identified a potential match.

RTI organized a meeting at JSC with the NASA researchers, the special education problem statement leader, the TU office, and the director of biomedical engineering services for Texas Children's Hospital in Houston (who agreed to serve as an advisor to the Team). In September 1991, the group met at JSC and discussed how the technologies might be best applied to help medically fragile special education students and defined the characteristics required of a corporate partner that would apply the technology.

Results

One of the medical monitoring equipment companies contacted by the Team in developing the problem statement possesses the qualifications determined by the group. The company was contacted and briefed by the Team. The Vice President of the Advanced Products division has agreed to meet with the group in November at JSC. At that meeting, the participants will determine if the NASA technology can add value to the company's products that will ultimately benefit the students and the company. If so, then a project plan will be developed for an Applications Engineering Project.

The RTI Team has also set up a meeting with the program directors at the Office of Special Education Programs (OSEP), in Washington, DC to determine federal programs that might support this initiative and provide funding leveraging. This office was recommended by a contact of the Center for Special Education Technology and by researchers at RTI who currently work with the OSEP.

The Special Education Initiative has received publicity in the special education field. The Team has been contacted by other special education technologists and the initiative was featured in the Summer 1991 issue of The Marketplace, a newsletter funded by the Department of Education.

SECTION 3.0: MAJOR INITIATIVES

Plans

The medically fragile children effort will proceed as above. The draft ICAT problem statement is expected in November; the Team will again work with industry, advisors, RTI staff, NASA, and the expert panel to develop specifications, match technology, and locate funding sources for this problem area. As this problem statement moves into process, the expert panel, now with an understanding of the TU process, will reconvene to discuss new appropriate problem areas in special education that might benefit from NASA expertise.

MYOELECTRIC PROSTHESIS INITIATIVE WITH THE LIMBS OF LOVE FOUNDATION

RTI Team Personnel: Daniel L. Winfield

Introduction

There are approximately 100,000 arm amputees in America today, of which 10% are under age 21. Approximately 300 children per year are born without a hand and an additional 200 per year lose hands as a result of trauma. There are two general types of prosthetic arms in use: (1) body-powered shoulder harness and (2) myoelectric (battery powered, controlled by electrical signals from muscles). In either case, hands are limited to one active degree of freedom, e.g. opening and closing of a hook. Despite such rudimentary technology, a myoelectric arm prosthesis will cost between \$6,000 and \$14,000. Maintenance costs are significant as well due to less than desired reliability in the electronics and due to wear and tear on the materials. For children who will outgrow a prosthesis every 12-18 months, the on-going cost can be quite substantial. In addition, no myoelectric hands are currently produced in the United States.

Recognizing many areas of potential technical advancement, RTI has worked with Johnson Space Center and the Limbs of Love Foundation in a new initiative to identify opportunities to apply advanced technologies toward a next generation myoelectric hand to be manufactured in the United States. The Limbs of Love is a private, consumer-oriented foundation which procures myoelectric prostheses for children in need, and more recently has become interested in seeing prostheses developed with improved capabilities, increased reliability and reduced costs.

Process and Interim Results

RTI worked with the Limbs of Love and JSC to plan a workshop on May 30-31, 1991 at Johnson Space Center. The Limbs of Love sponsored the travel of several experts from across the country and arranged for participation by several Houston-based rehabilitation specialists. RTI organized the agenda and served as moderator for the workshop which was quite successful. The initiative was given the name "An American Initiative: The Next Generation of Myoelectric Prostheses." Two important factors govern the mission, objectives and plans for this initiative. It is to be (1) driven by the needs of the consumers and (2) multiinstitutional and multidisciplinary in order to leverage the expertise and resources of many academic, govern-

SECTION 3.0: MAJOR INITIATIVES

ment and private organizations. Included among the Amercian Initiative participants are:

- Stanford University
- Northwestern University
- University of New Brunswick
- University of California-Los Angeles
- University of Utah
- The Institute for Rehabilitation Research
- Duke University
- Liberty Mutual Insurance Co.
- Shriner's Children Hospital
- Rice University
- Texas Scottish Rite Hospital

Participants at the workshop volunteered to write summary papers on 15 areas of need in the prosthetic field. While some of these relate to research, education, and limb-banking, most will describe specific technical needs, including:

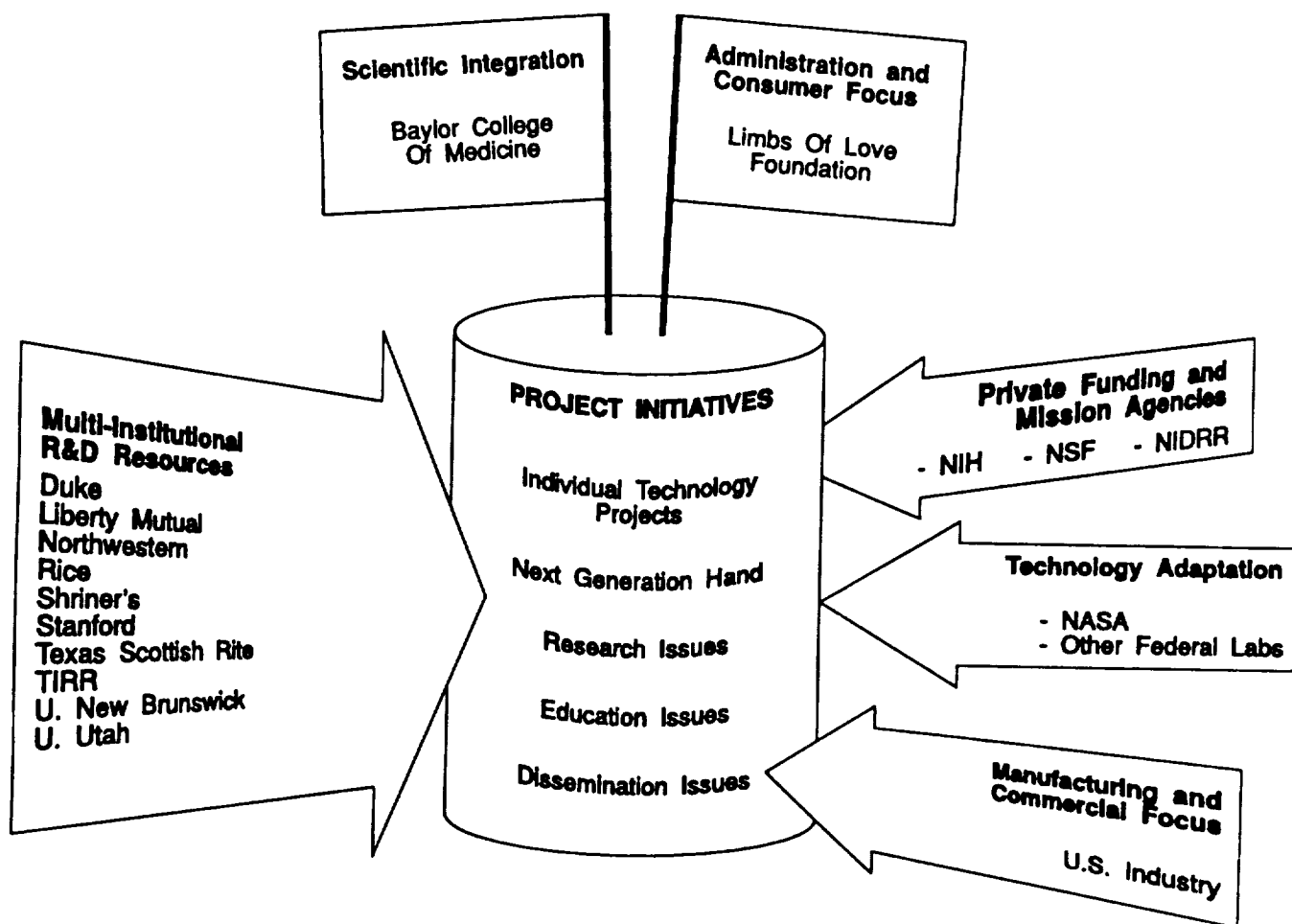
- Multiposition Thumb
- Compliant Joints and Grip Surfaces
- Auditory Feedback
- Multichannel Myoelectric Control (Multiple Degrees of Freedom)
- Improved Glove Materials
- Improved Batteries
- Powered Wrists

RTI has completed a report from the workshop summarizing the results of specific working group topics and designated action items. NASA is providing access to the NASA LIFENET electronic communications system to facilitate communications between participants. The initiative is using LIFENET as a means to have the summary papers reviewed and commented upon by all participants, with RTI coordinating finalization of these papers.

Plans

RTI will continue to work with the participants to finalize the summary papers and develop problem statements where appropriate. A meeting scheduled for Nov. 22 will determine the role of the Baylor College of Medicine and The Institute for Rehabilitation Research as scientific lead for the Initiative as well as the role of NASA and JSC, in particular. We anticipate several problem statements, merging one or more of the summary papers, will be developed by RTI and circulated to NASA and other organizations. The Initiative will prepare a binding statement which ties together the summary papers and the overall objectives and will use this document to solicit private contributions and to

pursue co-funding with other agencies such as the National Institutes of Health, the National Science Foundation and the National Institute on Disability and Rehabilitation Research. RTI will assist in developing specific project plans for the next NASA TU POP call.



NASA/AMERICAN CANCER SOCIETY TECHNOLOGY INTEGRATION PROGRAM

RTI Team Personnel: Daniel L. Winfield

Introduction

The RTI Applications Team has supported this initiative between Kennedy Space Center and the American Cancer Society-Florida Division for several years. The initiative has been successful in developing joint projects, costshared by ACS, NASA and industry, e.g. the flow cytometry project which ACS and industry investment of \$252K and \$200K leveraged against NASA TU funding of \$289K. While not a new initiative, it is worthy of review as a successful model program to identify and support technology transfer opportunities. RTI's experience played an important role in developing the operating procedures for this program. These procedures are summarized in this overview, while individual projects under the program are covered within the "New Problem Statements" and "On-Going Projects" sections of this Annual Report.

Process

The program is administered by a NASA/ACS Committee with members from the ACS staff, ACS medical volunteers, KSC TU staff, and RTI Team staff. This committee meets three times per year to review project concepts, develop recommendations for new projects, review funding decisions, review on-going project progress, and develop improved procedures for the program. The program follows a step-wise progression (shown graphically on the following page):

1. Solicitation of project concepts from Florida-based investigators. Project statements must discuss the cancer relevance, the technology needed for implementation, and the potential for commercialization.
2. The Committee reviews the project statements for cancer relevance and fit with the program objectives and forwards them to the RTI Team.
3. The RTI Team conducts a literature review and consults with experts, including the problem originator, to better define the problem and to identify current technology and active research.
4. To identify potentially applicable NASA technology, the RTI Team conducts a search of NASA technical reports files, circulates project statements to the NASA Field Centers, and contacts pertinent Field Center personnel.

5. Based upon our analysis in steps 3 and 4, the RTI Team makes a report and recommendation back to the Committee as to the match with NASA technological expertise and the likelihood of developing a successful project.

6. If approved by the committee, the originator is asked to work with the RTI Team and the NASA personnel involved to more fully evaluate the opportunity and to develop a complete project plan.

7. The RTI Team helps the participants develop a proposal to be submitted to ACS and an Applications Engineering Project Plan to be submitted to the NASA TUO. The RTI Team frequently supports the participants by comparing the concept to existing or alternative approaches and by identifying interested industry participants.

8. The proposal and project plan are sent through separate (concurrent) review channels at ACS and NASA, respectively.

9. If funded, the projects are implemented, and RTI maintains relationship with the participants to help resolve any problems that arise during the project. Results

Through this process, we have developed a unique project in which new flow cytometry instrumentation is being developed to meet the common needs of NASA Life Sciences and the clinical oncology community. Another project, which is attracting substantial industry interest, is the application of advanced processing methodologies, including neural networks, to perform image classification for early detection of difficult-to-diagnose tumors, e.g. ovarian cancer.

A second mode of operation has been found to be successful as well. In this case, the RTI Team contacts each NASA Center to solicit from NASA engineers and scientists ideas on how their technology research and development may be applied to cancer applications. These ideas are forwarded through the TUO to RTI and ultimately to the committee, which makes a determination of cancer relevance. Appropriate ideas are then forwarded to potentially interested cancer clinicians in the state of Florida who are asked to respond with project statements. Once these project statements are received and reviewed, the process picks up with step 6 above.

NASA-generated concepts have led to four projects which are now in steps 6-8 above. RTI assisted in developing two proposals (Video Screening for Melanoma with JPL and Flow-Through Immunoaffinity Cell Separation with MSFC) that are pending funding decision at ACS at this time. We are also assisting potential collaborators in a plan to develop a Panoramic Cystoscopy

System (MSFC) and to evaluate cancer applications of Rotating Cell Culture Vessel technology (JSC).



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4.0 BASIC CONTRACT STATUS

This section summarizes the status of the deliverables for the basic Technology Applications Team contract (NASW-4367) with RTI. Status reports for the contract add-on tasks are presented in Section 5.0.

The RTI Team's results in meeting its contract requirements are summarized in Table 1. Problem statements prepared by the Team during the reporting period are presented in Section 6.0. In addition to these new projects initiated this reporting period, the RTI Team continued to assist the NASA Field Centers in developing and monitoring projects initiated in previous contract periods. The RTI Team's activities in the coordination of these ongoing projects are described in Section 7.0.

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

**TABLE 1: CONTRACT STATUS
OCTOBER 1990 THROUGH SEPTEMBER 1991**

Problems prepared by Team	Opportunity	RTOP	Category	Center
Automated Data Acquisition and Analysis of Highway Pavement Cracking	YES	--	A	LaRC
Thermal Insulation for Refrigerators	--	--	M	--
Improved Natural Gas Leak Pinpointer	--	--	E	--
Containment of Paint Removed from Steel Structures	YES	YES	I	SSC
Deployable Structures Technology for Omnimax Theatres	YES	--	A	LaRC
Improved Technologies for Kuwait Oil Well Control	YES	--	I	LaRC/KSC
Reconfigurable Modular Manipulator System	YES	--	A	GSFC
Sprayed Zinc Coating for Corrosion Control of Reinforcing Steel in Bridges	YES	--	M	KSC
Braille Devices to Allow Media Access	--	--	R	--
Durability and Reliability of Externally Powered Elbow Prosthesis	YES	YES	R	MSFC
* Impending-Failure-Detection Expert System for Continuous Miner Motor/Hydraulic Subsystems	YES	--	A	GSFC
Improved Telecommunications for the Hearing Impaired	--	--	R	--
* Man-Machine Interface Rapid Prototyping Workstation for Continuous Mining Control Consoles	YES	--	A	GSFC
Monitoring and Life Support of Medically Fragile Children in the Educational Setting	YES	YES	R	JSC
Artificial Aurora Educational Museum Display	YES	--	E	MSFC
Computer Disc Drive Mechanical Problems	YES	--	E,M	JSC, MSFC

TABLE 1: CONTRACT STATUS
(Continued)

Problems prepared by Team	Opportunity	RTOP	Category	Center
Detection System to Identify Wetwood in Standing Living Trees and in Cut Logs and Boards	--	--	I	--
Mine Detection	YES	--	E	GSFC, SSC
Motion/Torque Sensor for Measuring In-Vivo Hip Implant Stability	YES	--	B	LaRC
Portable, Powered Seat Lift	YES	YES	R	MSFC
Thermal Insulation Coatings	--	--	M	--
Treatment of Wastewater Containing Nonionic Surfactants	YES	YES	I	ARC
PROBLEMS REFERRED BY FIELD CENTERS REQUIRING SIGNIFICANT TEAM ACTIVITY				
Flow-Through Immunoaffinity Device for Cell Separation	YES	YES	B	MSFC
Water Window X-Ray Microscope	YES	YES	B	MSFC
Capaciflector	YES	--	A/E	GSFC
PMR-II-50 and VCAP Polyimide Market Assessment	YES	--	M	LeRC
Convolver for Real-Time Signal Processing (CRISP)	YES	--	E	LaRC
Rotating Cell Culture Vessels	YES	YES	B	JSC

KSC = Kennedy Space Center

ARC = Ames Research Center

R = Rehabilitation E = Electronics

JPL = Jet Propulsion Laboratory

SSC = Stennis Space Center

B = Biomedical M = Materials

JSC = Johnson Space Center

LaRC = Langley Research Center

I = Industry A = Automation

LeRC = Lewis Research Center

HQ = NASA Headquarters

MSFC = Marshall Space Flight Center GSFC = Goddard Space Flight Center

* Problem statements developed under the auspices of a subcontract with Martin Marietta (see page 1)

5.0 ADD-ON TASK STATUS

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

- TASK 2: CAD/CAM for Custom Orthopedic Shoes
- TASK 3: Optimization of the Parameters of the Rotating Reactor

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

- TASK 1: AdaNet Program Support
- TASK 4: JSC Outreach Program

Task 1: Adanet Program Support

RTI Task Leader: Robert Wallace
Start Date: December 5, 1988
Completion: October 9, 1990

Background

In Fiscal Year 1988 NASA, Department of Defense (DoD) and the U.S. Department of Commerce entered into a joint program to establish AdaNet – a multifaceted project to screen, acquire, package and disseminate high value-added Ada software products developed under government programs. NASA seeks to achieve early successful transfers of NASA-derived Ada software products through several focused applications projects. The NASA Technology Applications Team at RTI has tracked the increasing use of the Ada programming language within NASA and the DoD.

Objectives

The objectives of this support effort are to assist the NASA Headquarters Technology Utilization Office in identifying NASA-developed Ada software products and establishing possible Ada-based applications projects to serve as demonstrations of NASA Ada software technology transfer. The RTI TATeam supported NASA Headquarters on the AdaNet initiative by identifying "focused" industrial application project opportunities. Another objective of the project is to develop collaborative efforts with other agencies to enhance and speed the transfer of NASA Ada technology into American industry.

Status

Several AdaNet Project status and planning meetings were held early in calendar year 1990 to formalize project team plans and activities for the remainder of FY90 and for FY91. Meetings at NASA HQ and in Charleston, West Virginia, highlighted a need to seek opportunities for the earliest possible public demonstrations of NASA Ada software technologies. Several on-the-shelf NASA Ada software technologies were identified as excellent candidates for demonstration at the NASA-supported Technology 2000 exhibition in November 1990. Two specific candidates for demonstration at Technology 2000 were ART-Ada developed under NASA funding by Inference Corporation of El Segundo, California, and CLIPS/Ada also developed under NASA funding by Barrios Technologies of Houston, Texas.

ART-Ada supports the development of expert system applications for deployment in specified Ada environments such as the NASA Space Station Freedom program. ART-Ada is fully integrated with Ada. This allows Ada subprograms to be called from ART-Ada rules. Additionally, ART-Ada provides a public Ada interface package that can be called from Ada programs.

CLIPS-Ada represents an Ada implementation of the very widely adopted NASA C Language Integrated Production System (CLIPS). CLIPS is called an expert system shell or tool and comprises three major elements:

- A fact list
- A knowledge base
- An inference engine.

Programs written in CLIPS consist of rules and facts. The inference engine decides which rules should be executed. An implementation of CLIPS in the Ada language immediately allows expert system functions to be embedded in historically procedure-based Ada applications, thus greatly expanding the feasibility of employing expert systems in Ada software environments.

Beyond demonstrations of ART-Ada and CLIPS/Ada at Technology 2000, RTI TATeam AdaNet activities included efforts to identify the relationship between AdaNet project goals and NASA-funded Lockheed Ada software programming efforts. Lockheed is the major contractor responsible for the Space Station Software Support Environment (SSE). The Space Station SSE will provide an integrated master tool set with associated procedures for all Space Station hardware and software for applications development simulation and testing.

Task 4: Lyndon B. Johnson Space Center Technology Utilization Outreach Support

RTI Task Leader: Stephen A. Lehrman
Start Date: December 5, 1988
Completion: January 1991

Background:

NASA's Lyndon B. Johnson Space Center (JSC) Technology Utilization Office has initiated an Outreach program focusing on Houston, Texas. The JSC TU Office has requested RTI assistance in this Outreach program.

Objective:

The objective of this task is to support the JSC TU Office in its Outreach program to the Houston community. The industry sectors targeted for this task are the petrochemical industry and the Houston medical community. In this effort, RTI will plan and conduct Outreach presentations to selected organizations and work with those groups to identify industry needs and match those needs with NASA technology.

Status:

RTI helped organize and served as moderator for a workshop sponsored by the Limbs of Love Foundation and held at JSC, May 30-31, 1991. The workshop was extremely successful in defining the technical, clinical, and programatic needs for a new initiative ("An American Initiative") to develop improved upper limb prostheses. Participants volunteered to write technology need summaries to be used by RTI/NASA as problem statements. NASA has provided the NASA LIFENET System for electronic communications among the participants. RTI has prepared a report from the workshop.

Also, RTI met with officials from the City of Houston to discuss a NASA/U.S. Conference of Mayors (USCM) initiative to match NASA JSC technology with priority problems that face the city of Houston. The Mayor of Houston, Kathryn Whitmire, contacted the JSC Center Director by letter to show her interest in the program and her desire to work with JSC in this important area. The City submitted a number of problem areas and the RTI Team has provided an initial evaluation to focus on those most likely to lead to successful applications projects.

6.0 NEW PROBLEM STATEMENTS

Problem Title: Automated Data Acquisition and Analysis of Highway Pavement Cracking

Date of Preparation: November 1, 1990
Source of Problem: Texas State Department of Highways
and Public Transportation (SDHPT)
RTI Team Personnel: Stephen A. Lehrman, Jeff Antley

I. Technology Requirement:

An automated system is required to capture pavement images using a vehicle traveling at highway speeds to determine the type (i.e. longitudinal, transverse, alligator, etc.), extent, and severity (size) of cracking.

II. Background:

Each state is responsible for implementing a pavement management system including collection of highway data. This data includes highway profile or surface roughness, rut depth, failures, crack identification, and skid resistance. Both portland cement concrete and asphalt pavements are affected. Systems have been designed to automate the collection of most of this data. However, the identification and logging of cracks, known as surface distresses, remains mostly a manual process.

Surface distress surveys are conducted by field crews on an annual or biannual schedule. The field crews are trained to classify and quantify surface distresses based on their visual observations. A scoring technique is used to determine the percentages of cracking, and other attributes leading to either a deduction of points or an addition of points. In the first case, a score of 100 points is a perfect pavement and a score of 65 or less typically indicates excessive cracking or roughness. In the second case (not used in Texas), scores are divided into maintenance (50-399), overlay (400-699), and reconstruction (over 700). Each state has its own unique pavement rating and scoring system. The problems with using field crews are that the surveys are labor intensive, the results are subjective, and it is unsafe for the crews to be collecting information on the sides of highways (c.f. attachment from Scientific American, October 1990).

SECTION 6.0: NEW PROBLEM STATEMENTS

The state highway departments can realize a large cost savings if pavement cracking can be identified and classified in a timely fashion. Once severe cracking occurs, it becomes very expensive to repair or replace the pavement.

A. State of the Art:

Imaging systems have been developed to collect image data of the highway surface while the equipment is traveling at 55 to 60 mph. The Texas SDHPT uses the ARAN, Automatic Road Analyzer system, produced by Highway Products International (HPI), Inc. of Canada, for their high volume pavements. The Texas ARAN uses a Panasonic 300 cle CCD camera to record the Right of Way and a Sony DXC remote head camera to record the pavement surface. This allows videotaping of a full twelve feet of pavement width. One of the problems with the videotape system is that the CCD camera system has a resolution of 700 lines while the videotape has a resolution of only 400 lines. This makes narrow cracking difficult to detect and classify.

The videotape can be manually reviewed frame-by-frame and any surface distress can be noted, classified, quantified, and entered to a computer record associated with the frame. Like the manual visual survey, this review is a labor intensive process. The Texas SDHPT has a research contract with Texas A&M University to develop computer software to automate the image analysis. Current operating and analysis cost for the Texas ARAN is \$20 to \$30 per lane depending on condition. Other operating costs reported for the ARAN are as high as \$46.43 per lane mile. (Ref. 1)

VideoComp, Inc., of Boise, Idaho, and Roadman-PCES, Inc., of Sparks, Nevada, have each developed automated pavement management systems of similar caliber to the ARAN. These three systems represent the state-of-the-art in pavement management.

The VideoComp system was developed under contract to the Idaho Transportation Department (ITD). VideoComp and Boise State University tested the equipment between July 1, 1988 and June 30, 1990, and deemed it suitable for use by ITD. The VideoComp system, like ARAN, uses CCD cameras to record images of the road on videotape. Cameras, videotape, lights, and a generator are housed in a trailer pulled behind another vehicle. VideoComp, however, includes postprocessing computer software capable of selecting images with surface distresses, digitizing them, storing them, and performing subsequent analysis for crack classification. This information is fed directly to ITD's Pavement Performance Management Information System (PPMIS) in a "crack index" format. The VideoComp system is restricted by the resolution of the videotape, and suffers reduced reliability at speeds less than 30 mph. Cost per lane mile is unknown. (Ref. 2)

Roadman-PCES's PDI-1 system differs in many ways from ARAN and VideoComp. It uses 4 CCD cameras, at highway speeds, to input images. These images are filtered, bitmapped, and refiltered to reduce the number of bytes per second of raw data to be stored. This preprocessing reduces the data from 21,626,880 bits per second (total from all four cameras) to 675,680 bits per second. This data is then stored on Digital Analog Tape (DAT) format, which can handle 1,464,000 bits per second and has 10.4 gigabits of total storage. The PDI-1 performs only the preprocessing data compressing in real-time; crack analysis is postprocessed. In postprocessing, PDI-1 analyzes average crack width, but crack classification remains a manual duty. Costs for this system are \$30.00 per lane mile. (Ref. 3)

The Westinghouse Science and Technology Center in Pittsburgh is experimenting with a road analysis system unrelated to visual scanning. The process electromagnetically tags newly constructed roads and bridges by introducing inexpensive ferromagnetic particles to the concrete. These evenly distributed particles give the road a uniform signature in response to a small current or magnetic field. Degradation of the road structure, by way of potholes or cracks, causes the signature to change.

These state of the art systems are not satisfactory, especially for states with as many road miles as Texas. Some companies are not willing to sell the technology (making it hard to lease when considering the approximately 60,000 roadway miles to be rated after implementation of the PMS in Texas). Others, once they do sell the technology, provide only executable code and patented hardware, thus making changes either impossible to do or very expensive. Although the distresses to be analyzed are common to most pavements throughout the country, most vendor software packages are generic. Therefore each software package must be customized to fit a particular need. Smaller states, counties, and other local authorities are more willing to make use of the available data collection systems (usually through service agreements) in their present status and use the generic reports produced by the vendors.

The systems described above also suffer from the videotape resolution problem as well as lighting problems. PCES has done more to alleviate its problem by using line scanning imagers and special lighting of a shrouded section of pavement. This has presented its own set of unique problems, such as very expensive lighting systems (approximately \$300,000), and temperature sensitive cameras (requiring refrigerated enclosures). The shrouded section is one way to eliminate shadows from the video image, another is to collect the data at night under uniform lighting. Night operation has its own problems, such as driver fatigue and distractions to other drivers from the lights. No amount of artificial lighting can remove other non-distress images that are seen on the pavement and are candidates for misinterpretation, including such things as skid marks, oil drips, oil patches, mud

SECTION 6.0: NEW PROBLEM STATEMENTS

and asphalt drips. Problems such as these require monitoring by personnel familiar with condition rating so that they can make corrections.

All the systems store their video images on some type of sequential access media video tape for most and DAT for PCES. This access and rating time makes manual and, to a certain extent, automated rating time consuming. The optical disk recorders purchased for the Texas ARAN to eliminate this sequential access problem proved to be too shock sensitive to be mounted in a moving vehicle. Thus, most systems still use videotape. The current digitization and automatic ratings techniques are slow and require some user interface for sections which failed the automatic rating. Some problems are described in the previous paragraph.

All the systems described thus far require a 100% imaging along the length of the surveyed pavement. All surveyed pavements do not contain distress and therefore do not require imaging. Capturing images only when they are needed would vastly decrease the required image storage space of these systems. Another obvious benefit would be decreased time to rate a section.

III. NASA Technology:

The Texas State Department of Highways and Public Transportation has expressed interest in several different NASA technologies for development with an automatic pavement management system. Possibilities include: equipment for mass data collection, increased data processing rates, laser technologies to measure rut depth, and the Transportable Applications Environment for ease of data management.

NASA's Jet Propulsion Laboratory (JPL), faced with vast amounts of raw data from remote-sensing satellites and interplanetary probes, has developed several innovations for fast image processing and data storage. K. Y. Liu and W. E. Arens have proposed an on-board synthetic aperture radar processor with the capability of digitizing 400 megabits per second. An optional Data Reduction Unit can compress data and extract information. Such a unit has the potential for real-time image processing capability. (Ref. 4)

Also from NASA's JPL is a proposed laser scanner for use on a self-guided robotic vehicle. The scanner is composed of laser diodes, turned on and off in sequence (row by row, column by column), to scan an area. This process eliminates any mechanical motion necessary to scan an area. The reflected beams are intercepted by a CCD camera, and a microprocessor calculates the distance to the object. Range is estimated to be between 0.5 and 5 meters for one laser array/CCD camera, and the accuracy of the measured distance is believed to be between 1 and 3 percent of the range (hence, 5 to 150 millimeters). It is thought that the lack of

mechanical motion makes this design immune to the wear, stress, and breakage to which conventional scanners are subject. (Ref. 5)

The Land Analysis System (LAS), developed by NASA's Goddard Space Flight Center (GSFC) and the USGS EROS Data Center, is a public domain interactive software system designed for the analysis, display, and management of multi-spectral and other digital image data. LAS offers over 240 applications functions to process data types, including arithmetic/complex logical comparison between pixels, geometric transformations, image manipulation, spacial processing, and statistics. It relies on the Transportable Applications Environment (TAE) for user interface, due to TAE's versatility. Many facilities outside of NASA already use the TAE, including The Boeing Company, RAND Corporation, and the Department of Energy's Lawrence Livermore National Laboratory. Capabilities of the TAE extend to image processing; TSDHPT is interested in TAE technology for use with an APMS. (Ref. 6)

NASA's Lewis Research Center has implemented its own invention which digitally compresses, in real time, television image data. The device "is a digital CODEC (encoder/decoder hardware) which processes standard NTSC (National Television Systems Committee) composite color television signals in real time at an average of 1.8 bits/picture-element." The quality of the resultant images is the same as in the originals.

IV. Technical Requirements:

The Texas SDHPT has identified two specific technical requirements to improve the state-of-the-art. First, the SDHPT would like to see a better means for recording the video data. As noted above, the CCD cameras have a resolution of 700 lines while the videotape has a resolution of 400 lines. Improved video data acquisition equipment will enable the SDHPT to better discriminate cracking and help overcome the problems associated with shadows and anomalies.

The second technical requirement is faster image processing algorithms and image processing engines. With the system under development at Texas A&M, once the video data has been recorded it can be processed off-line. However, it is currently taking up to 3 minutes or more per frame to process the data. An order of magnitude improvement in the data processing is required.

Specific requirements of the data acquisition and image processing systems are:

- Ability to reliably detect cracks a minimum of 1/8" in width
- Ability to distinguish cracks from shadows, seams, or other anomalies
- Increased access time for rating and review

SECTION 6.0: NEW PROBLEM STATEMENTS

- Increased flexibility of locating other collected data and displaying data with images
- Fully automated image processing capacity to classify cracks by type and severity, and indicate location on roadway
- Easy report generating ability to present both network level PMS reporting (condition, trends, etc.) and project level PMS reporting (amount of rutting, cracking, etc. for a given section)
- High speed, if not real-time, data processing
- Equipment housed in a van or trailer (van mount preferred)
- High reliability at both highway speeds and lower speeds
- Usefulness in day and night environments
- Immunity to extremes of temperature, humidity
- Immunity to normal road conditions (dirt, smoke, vibration, etc.)
- Total collection and processing cost per lane mile of \$40.00 or less for competitiveness.

V. References:

1. Arkansas State Highway and Transportation Department. "Pavement Management Surveillance Systems Evaluation." Final Report, Transportation Research Project Number TRC8802, November 1988, p. 29.
2. Idaho Transportation Department. "Evaluation of Selected Devices for Measuring Pavement Distress." Technical Report to U.S. Department of Transportation Federal Highway Administration, June 1990.
3. McDaniel, L. D., Research Director, Roadman-PCES, Inc. Personal correspondence with author, August 22, 1990.
4. Liu, K. Y. and Arens, W. E. "Processing SAR Images on Board." JPL Invention Report NPO-17195/6667, January 1989.
5. Shimada, K. "Electronically Scanned Laser Rangefinder." NASA Tech Briefs, Volume 14, Number 5, May 1990, p. 46.
6. Wharton, S. W., et al. "The Land Analysis System (LAS) for Multispectral Image Processing." IEEE Transactions on Geoscience and Remote Sensing, Volume 26, Number 5, September 1988, pp. 693-7.

Problem Title: Flow-Through Immunoaffinity Device for Cell Separation

Source of Problem: American Cancer Society

RTI Team Personnel: Daniel L. Winfield

Background

This project was submitted by Laurel Karr, Marshall Space Flight Center, in response to a solicitation from the American Cancer Society-Florida, through RTI, for technology transfer projects applicable to cancer. Building upon cell separation research conducted for microgravity science applications, the investigators propose a device which uses PEG-monoclonal antibody conjugates to separate tumor cells from normal cells (see Figure 1). This will have application in antologous bone marrow transplantation and also to certain blood-born diseases.

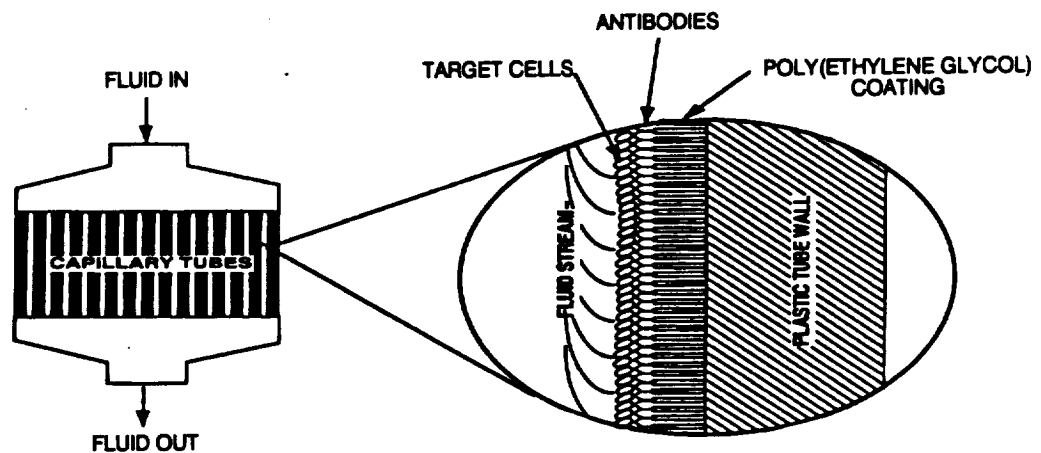


Figure 1: Flow-through immunoaffinity filter – Schematic

Principals

- Laurel Karr, MSFC
- Dipnarine Maharaj, University of Miami
- Milton Harris, University of Alabama-Huntsville

SECTION 6.0: NEW PROBLEM STATEMENTS

Status

The ACS-Florida has reviewed the project and identified a potential collaborator at the University of Miami. RTI has assisted Dr. Maharaj at the University and Laurel Karr to fully develop a project plan. They have submitted a proposal to ACS-Florida with the priority application being the separation of bone marrow stem cells. A decision is expected on this proposal by November 14, 1991. RTI worked with the TU Offices at MSFC and KSC to allocate \$20K in FY91 funding to initiate the project.

Action

Attend November 14th ACS-NASA meeting for final funding decision. Work with the principals to develop full implementation plan.

Problem Title: Improved Natural Gas Leak Pinpointer

Date of Preparation: October 18, 1990
Source of Problem: Gas Research Institute
RTI Team Personnel: Stephen A. Lehrman

I. Technology Required:

New technologies for pinpointing underground natural gas pipe leaks are required.

II. Background:

Gas Research Institute (GRI) would like to quickly, accurately, and remotely locate gas leaks emanating from the buried pipes of natural gas pipelines and distribution systems. The present approach consists of pounding a set of equi-spaced bar holes into the ground that are in alignment with the buried pipe and encompass the area of the suspected leak site. Gas concentration measurements are taken from each hole. The probable site for excavation and repair work is taken as the hole or holes with the highest gas readings. The process is time consuming and not always accurate.

A. State-of-the-Art:

Ground penetrating radar (GPR) has demonstrated an ability to operate at ground level from which it could detect and pinpoint the sites of gas leaks from buried pipes.¹⁻³ In the GPR work, impulse radar has been employed that operates in the low gigahertz range. Apparently, the escaping gas from the buried pipe alters the electrical properties of the soil in the immediate vicinity of the leak site, causing GPR echoes from the pipe to be altered in intensity and/or two-way travel time. However, the resultant depth profile data is complex and difficult to interpret.

Sonic methods have been a strong candidate for leak location for many years. Both active and passive methods have been investigated. In an active method, sound is injected into the gas within the main. The sound travels through the gas in the main and a fraction of the acoustic energy escapes at the leak aperture. The sound then passes through the soil to ground level where it is detected. In passive techniques, the sound of the leak itself is detected. In medium- and high-pressure distribution systems, sensors located in bar holes have successfully detected the sonic emissions from gas leaks.⁴ However, the detector was often required to be very close to the leak

SECTION 6.0: NEW PROBLEM STATEMENTS

site (approximately 1 ft.) before the leak signal was detected. Apparently, soil attenuation was excessive. Passive acoustic techniques cannot detect the leak unless turbulence is created by leaking gas escaping from the pipe. Passive acoustic techniques cannot detect the leak unless turbulence is created by leaking gas escaping from the pipe.

Optical fiber technology has been employed as another way to detect the acoustic emission from gas leaks⁵. In a laboratory study, it has been demonstrated that simulated gas leaks, as small as 1-2 Standard Cubic Feet Per Hour, can be detected and pinpointed by their perturbing effect upon a periodic train of light pulses directed down the fiber that was placed within the pipe. Adoption of such technology, with free passage of the fiber down the length of the pipe, would require significant and, perhaps, costly retrofitting to remove or redesign impediments such as main line shut off valves.

Both GPR and sonic techniques have attempted to use advanced data processing techniques to exploit the informational content of the desired signals. It was demonstrated, for example, that the adaptive learning network model could be employed with the acoustic spectrum of passive sonic emissions to identify the type of leak (mains, service lines, etc.) and the leak rate.⁶

Electric utility companies in New York City can trace leaks in dielectric fluid used to cool electrical cables by detecting liquid perfluorocarbon tracers (PFT) which are introduced into the dielectric fluid coolant within the pipes. The process, engineered by Brookhaven National Laboratory (BNL), uses a dual-trap analyzer (DTA) to detect trace PFT along the length of the pipe. When a leak occurs, the harmless PFT vapor rises to the street surface, acting as an invisible chemical flag marking the presence of a leak. The DTA can register 50 parts-per- quadrillion of PFT. The initial trial of the DTA system pinpointed a leak to within 1 foot.

III. Technology Constraints and Specifications:

It is desirable that the leak pinpointer would operate at ground level and locate the underground leak site in less than 30 minutes. The leak pinpointing technique should work without disturbing the ground in the area of the suspected leak site and without requiring direct access to the piping. The technique should involve equipment that is portable, safe and easy to use by field personnel. It should possess no interferences. A list of desired performance features is presented in Table 1.

**TABLE 1: Desired Performance Features for a
Natural Gas Leak Pinpointing Technique**

- Field portable
 - Ground level operation
 - Rapid (30 minutes or less)
 - Accurate (1 ft.)
 - No false alarms ()
 - User friendly
-

IV. NASA Technology:

NASA research has long focused on remote, non-intrusive detection of trace gases. Recently, Kennedy Space Center has been concerned with leak detection of propellant from the Space Transportation System. Ames Research Center and Jet Propulsion Laboratory have developed gas chromatographs and mass spectrometers for measuring gas particle concentration.

V. References:

1. Young, J.D.; A.K. Dominek; J. Izadian; B.R. Chen. "Development of Techniques to Pinpoint Natural Gas Leaks from Buried Pipes with an Underground Radar System." Ohio State University Electroscience Laboratory. Final Report for GRI, NTIS Order No. PB83-232694, GRI Report No. 80/0020, 1983.
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Problem Title: Thermal Insulation for Refrigerators

Source of Problem: Whirlpool Corporation

Date of Preparation: October 9, 1990

RTI Team Personnel: John G. Cleland, Stephen A. Lehrman

I. Technology Required:

A new lightweight, thermal insulation material or vacuum panel system for insulating refrigerator cabinets is required. The new material or system should be free of CFCs and provide a composite thermal resistance of R20/inch.

II. Background:

New environmental and energy requirements will affect the way refrigerators are manufactured in the 1990s. The Montreal Protocol of 1986 mandated a chlorofluorocarbons (CFC) production freeze, followed by a total phase-out by the year 2000. CFCs are used as the appliance refrigerant and to manufacture the foam insulation used in the refrigerator cabinet. Simultaneously, the U.S. Department of Energy is requiring that refrigerators be twice as efficient as they now are by the end of the decade.

Polyurethane foam is used to insulate refrigerators and freezers. The manufacturer builds the refrigerator cabinet and places a liquid mass of polyurethane between the cabinet inner and outer walls. The polyurethane contains CFC-11 that is used as a blowing agent. When the cabinet is heated, a chemical reaction takes place and the CFC-11 blows the polyurethane into a foam that fills the void between the cabinet walls.

Both the closed cell polyurethane foam and the CFC-11 in the foam cells contribute to the thermal insulation. Traditionally, CFC-11 has been the blowing agent of choice because its low vapor thermal conductivity (0.0092 BTU/ft-F-hr) provides good insulating properties and the slow mobility of the gas molecules through the cell walls provides long-term stability.

State-of-the-Art:

Hydrochlorofluorocarbons HCFC-123 and HCFC-141b have been suggested as replacements for CFC-11 as a blowing agent for foams. These materials have properties similar to CFC-11 but pose little or no threat to the ozone layer. Table 1 compares the atmospheric life, ozone depletion potential, and global warming potential for various blowing agents. HCFC-141b is flammable and handling such a material could require expensive plant redesign. Both HCFC-123 and HCFC-141b

have lower insulating ability than CFC-11. Also, HCFC-123 and HCFC-141b cause stress cracking and shrinkage of the ABS plastic used in the refrigerator liner walls, although this problem will probably be overcome by coating the plastic. Whirlpool believes that the use of HFCs and HCFCs is only an interim solution and that they too will be unavailable by the year 2000. For example, Sen. John Chaffee (R-RI) has already sponsored a bill to phase out HCFCs.

Carbon dioxide has been used as a blowing agent for polyurethane. However, the carbon dioxide can diffuse through the insulating foam and shorten the appliance service life. Also, the thermal insulation of carbon dioxide blown foam is twice that of CFC-11 blown foam thereby increasing the power consumption and decreasing the refrigerator efficiency.

Another potential insulation solution is vacuum panels. Thermalux, a Richmond, CA company, is developing a self-supporting aerogel vacuum panel that operates at about 1/10th atmosphere. Aerogels are microporous silica gels that are up to 97 percent air. The insulation can be made with a thermal resistance of R20 per inch of thickness and an anticipated lifetime of 15-20 years. At this time, the company is making six-by-six inch panels for testing.

Oak Ridge National Laboratory and General Electric have developed a low vacuum panel with silica powder as the filler. General Electric has never mass produced the panels because they question whether the edge seals of the panel could maintain the vacuum for the 20 year life of a typical refrigerator.

The Solar Energy Research Institute has developed a hard vacuum panel that consists of two sheets of stainless steel welded together by a laser beam. Glass beads or embossed glass sheets act as spacers to separate the metal sheets. Prototype panels are now being tested.

The refrigerator industry is proceeding cautiously with respect to vacuum panels. If an evacuated panel inside the refrigerator loses its vacuum, the refrigerator is of little use and virtually impossible to repair. The manufacturing process required to produce evacuated panels that maintain a vacuum for 20 years is very expensive.

III. Technical Requirements:

The ideal refrigerator thermal insulation would be a low cost, easily manufactured material that is free of CFCs and HCFCs. For comparison purposes, polyurethane foam costs \$0.015/(sqft-R-value) and is installed in about 4 minutes. The material should have a thermal resistance of R20/inch and show minimal degradation in thermal efficiency over 20 years. The material should be an integral part of the refrigerator wall mechanical structure.

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The refrigerator manufacturers want to meet the new Department of Energy requirements without changing the overall dimensions of the refrigerator. This means that in order to double the refrigerator energy efficiency, the thermal conductivity of the insulation must be reduced by 50%.

An alternative to foam insulation is to develop an evacuated panel system that will not lose its vacuum over the refrigerator design life. Either a soft vacuum using aerogels or silica powder or a hard vacuum is acceptable provided that the insulating capability of the evacuated panel can be assured for the 20 year life of the appliance.

IV. NASA Technology:

The Thermal Protection System (TPS) of the Space Shuttle is an efficient thermal insulator. The Reusable Surface Insulation Subsystem, of which the tiles are a part, is the major component of the TPS. White coated tiles are called low temperature reusable surface insulation and black coated tiles are known as high temperature reusable surface insulation. Flexible reusable surface insulations are felt blankets and advanced flexible reusable surface insulation is a ceramic fiber base material. NASA Contractor Report 4227 titled Thermal Protection System of the Space Shuttle documents the materials used in the TPS. Questions concerning the use of TPS material prompted the inquiry from Whirlpool.

NASA material scientists have been experimenting with new ceramic powders such as silica aerogel, silica, and alumina. Powder insulation characteristics that are desirable are particle size less than a micron with low thermal conductivity.

NASA has considerable experience in vacuum system development. A method for assuring that an evacuated panel can sustain its vacuum for 20 years would advance the application of this technology.

V. Participants:

The Association of Home Appliance Manufacturers (AHAM) and the federal government have created the Appliance Industry-Government CFC Replacement Consortium to perform basic research on alternatives to using CFCs. The Consortium is a wholly owned subsidiary of AHAM. Members of the Consortium include Admiral, Amana Refrigeration, GE Appliances, Sanyo, Sub-Zero Freezer Company, W.C. Wood Company, Whirlpool Corporation, and White Consolidated Industries. The Department of Energy and Environmental Protection Agency also participate. Proposed solutions will be discussed with AHAM for technical and commercial feasibility.

Status

The Team will recontact Whirlpool Corporation to determine their current plans for implementing NASA (or other) insulation solutions.

Table 1 - Comparison of Blowing Agent Properties

Compound	Atmospheric Life (Years)	Ozone Depletion Potential	Global Warming Potential
CFC-11	60	1.0	1.0
HCFC-123	2	0.02	0.02
HCFC-141b	8	0.1	0.09
HFC-152a	2	0	0.03

Ozone Depletion and Global Warming Potentials are relative to CFC-11. Reference: R&D Magazine, May 1990 page 62.

Table 2 - Vapor Thermal Conductivity

Potential Blowing Agent	Thermal Conductivity (BTU/h-ft-F)x10e3
CFC-11	4.7
Nitrogen	15.1
Carbon Dioxide	9.6
HCFC-123	5.3
HCFC-141b	5.3

Reference: Machine Design, May 24, 1990 page 110.

Problem Title: Water Window X-Ray Microscope

Source of Problem: American Cancer Society

RTI Team Personnel: Daniel L. Winfield

Background

This project was submitted by Richard Hoover, Marshall Space Flight Center, in response to a solicitation from the American Cancer Society-Florida, through RTI, for technology transfer projects with relevance to cancer. Using two dimensional multilayer diffraction coatings and precision optics fabrication methods (developed for use in X-ray telescopes) the investigators propose to develop a microscope capable of imaging below 44 Angstroms. Below this region, water is transparent (thus the term water window) but carbon-based molecular structures can be imaged. This opens the possibility of imaging components with living cellular structures, leading to many applications as a basic research tool in cellular biology.

Principals

- Richard Hoover, MSFC
- Phil Baker, Opti-Scan Technologies
- Troy Barbee, Lawrence Livermore National Lab
- Bill Brinkley, Baylor College of Medicine

Status

Having reviewed the project statement, the ACS-Florida determined they did not have an investigator suitable to collaborate with NASA on this project. RTI has requested that ACS forward it to their National Headquarters for an informal review.

RTI has contacted the NIH Biomedical Research Technology Program and the National Science Foundation which fund technology development projects of general biomedical or biological interest. Both groups expressed interest in the project, but they require proposals from universities. One of the principals has formed a company to commercialize the x-ray microscope and submitted a business plan for our review. The project has been initiated with funding of \$50K from the MSFC TUO. NASA HQ Code CU has allocated \$180K for FY92.

Action

RTI will continue to coordinate attempts to secure co-funding sources.

Problem Title: Capaciflector Capacitive Proximity Sensor

Source of Problem: Dr. John Vranish, Robotics Branch, Goddard Space Flight Center

RTI Team Personnel: Dean Hering

Background

This project was pursued at the request of Dr. John Vranish at Goddard Space Flight Center as a result of his research and development in capacitive sensing technologies and knowledge of commercially available sensors. The Capaciflector provides a simple, compact, and unobtrusive sensor for robotic collision avoidance (and general purpose capacitive proximity sensing). The easily mountable sensor may potentially provide a superior technology for robotic manipulator collision avoidance, path planning, and object sensing than currently available devices.

Status

The Team developed a prospectus for the Capaciflector capacitive skin sensor being developed at Goddard Space Flight Center. The Capaciflector Prospectus details the technology, current practice, market potential, and current status of the Capaciflector. The Prospectus provides a mechanism to distribute information of interest to the technical, management, marketing, and administrative staff of interested corporations.

The Prospectus was distributed to potential industrial partners; two groups of companies responded, requesting to participate. Independent of the TU Office, the GSFC researcher pursued commercialization through the Joint Sponsored Research Program, which identified several companies that NASA might approach to interest in the Capaciflector. In June, Dean Hering (RTI Applications Team) met with Don Friedman (GSFC TUO), Ray Gilbert (HQ code CU), Kevin Barquinero (HQ, code MT), Paul Masson (AmTech-JSR Program), and Karen Robbins (AmTech-JSR Program) at Goddard Spaceflight Center to join forces in commercializing the Capaciflector technology. Due to the current state of development of its components, the Capaciflector lends itself well to both the **Joint Sponsored Research (JSR) Program**, which focuses on technologies in the early stages of research and development, and to an Applications Engineering Project (AEP), which focuses on applying more mature technology in directed applications. To maximize the potential benefits of transferring the technology, Mr. Hering and Mr. Masson are coordinating efforts and companies in the first joint JSR-AEP technology transfer. The technology will be offered to all companies first through the JSR

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Program and then through the AEP Program. The task plan and linkage between the two TU network elements will provide a working model for future collaborations and referrals between the two TU network programs.

Problem Title: Containment of Paint Removed from Steel Structures

Date of Preparation: March 27, 1991
Source of Problem: TAB Industries
RTI Team Personnel: Stephen A. Lehrman

Technology Requirement:

A low-cost, containment system is required to contain lead or zinc based paint removed by abrasive blasting from bridges, water towers, or other steel structures.

Background:

Over 200,000 steel bridges in the United States have been coated with paints containing high concentrations of zinc, lead, or toxic solvents. When the bridges need to be repainted, it is necessary to remove the existing paint to bare metal. Sandblasting using abrasive sand or steel shot is one of the more common methods used to remove the paint.

In 1976, the U.S. Congress enacted the Resource Conservation and Recovery Act (RCRA). This act required paint containing leachable lead in concentrations greater than 5 ppm to be handled as a toxic substance. In 1983, the Transportation Research Board reported that sandblasting blew lead paint off bridges and onto soil, water, and streets. Environmental agencies from several states responded by requiring the containment and disposal of the lead based paint residue in accordance with the RCRA law.

The federal and state Departments of Transportation have been working with sandblasting contractors to devise containment systems for paint debris. These containment systems typically consist of wrapping the bridge in plastic or cloth and using vacuum pumps to create a negative pressure. Each containment system is unique. Workers blasting inside the containment wear air-fed helmets to protect them from the dust.

Because of the shape of bridges and water towers, the containment systems do not develop a tight seal. On some sandblasting projects, it has been necessary to lower the containment during high winds resulting in the dispersion of the paint residue. Also, there is concern about excessive wind loads being transmitted from containment systems to water towers that are not designed for these forces. The U.S. Occupational Safety and Health Administration is concerned about the health effects of the lead dust on the containment workers. There have been a few cases

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where the workers exhibited increased lead levels in their blood. It has not been confirmed whether sandblasting in the enclosed containment was or was not the cause of the lead poisoning.

Technical Requirements:

A containment system needs to be developed that is adaptable to the shape of bridges, water towers, and other steel structures. The containment system can be a full enclosure of the structure or a mini-containment that encloses part of the structure at a time. It is anticipated that the containment system will probably be of a size that it must be moved from location to location at the job site in order to complete the entire work.

The enclosure material needs to be designed to withstand the impinging of sandblasting material. This material should be translucent, flexible, and field repairable. Conventional six mil polyethylene plastic is not suitable for the enclosure material.

The containment system must be able to seal against the structure so that no paint residue escapes. Seals are required to seal the containment to plane surfaces (tank sides), round surfaces (pipes), and structural shapes (beams and angle iron). Existing vacuum pump technology is probably adequate to maintain a slight negative pressure within the containment and control the paint dust.

NASA Technology:

NASA technology in modular, erectable structures is desirable. Telescoping legs would allow the containment system to be field adjustable. Gimbaled joints would allow the containment to better fit the shape of the structure. Composite materials could be used to develop lightweight, high strength scaffolding.

Inflatable, form fitting seals are necessary. These inflatable seals would seal against round or plane surfaces thus preventing the release of paint dust. The containment enclosure could be fabricated from plastic film reinforced with continuous fibers. The enclosure could be attached to the containment structure using a super-velcro material for ease of assembly.

For water towers, NASA technology could be used to design a free standing containment system out of composite materials that would not transmit any additional wind loads to the water tower structure. Finite element programs such as NASTRAN could be used for this design.

Participants

The principal participant is Mr. Lynn Rouse, President of Tab Industries which is a small business located in Mississippi. The U.S. Department of Transportation, the

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U.S. Occupational Safety and Health Administration, and the U.S. Environmental Protection Agency are all being contacted regarding their participation.

Problem Title: Deployable Structures Technology for Omnimax Theatres

Date of Preparation: May 17, 1991

Source of Problem: Chicago Science Museum

RTI Team Personnel: John Cleland, Jeff Antley

I. Technology Requirement:

Large deployable structures technology to be used for cleaning the surfaces of OmniMax theater screens is required.

II. Background:

Omnimax theatres are designed around the large viewing screen, which is a hemisphere tilted at a thirty degree angle. Omnimax theatres strive to produce a unique visual experience by filling the viewer's field of vision and by presenting sharp, detailed movie images. Some of these theatres are approaching ten years of service. During this time, no effort has been made to clean the screen's fragile fabric panels. The buildup of dust and other particulates is interfering with the quality of the viewed images. These panels cannot be removed for cleaning, for none has ever been successfully replaced. Satisfactory cleaning could be performed by passing a vacuum cleaner very close to the surfaces, but the problem of reaching them is prohibitive; the height of the screen above the floor approaches forty feet in areas (See Figure 2). Given no other

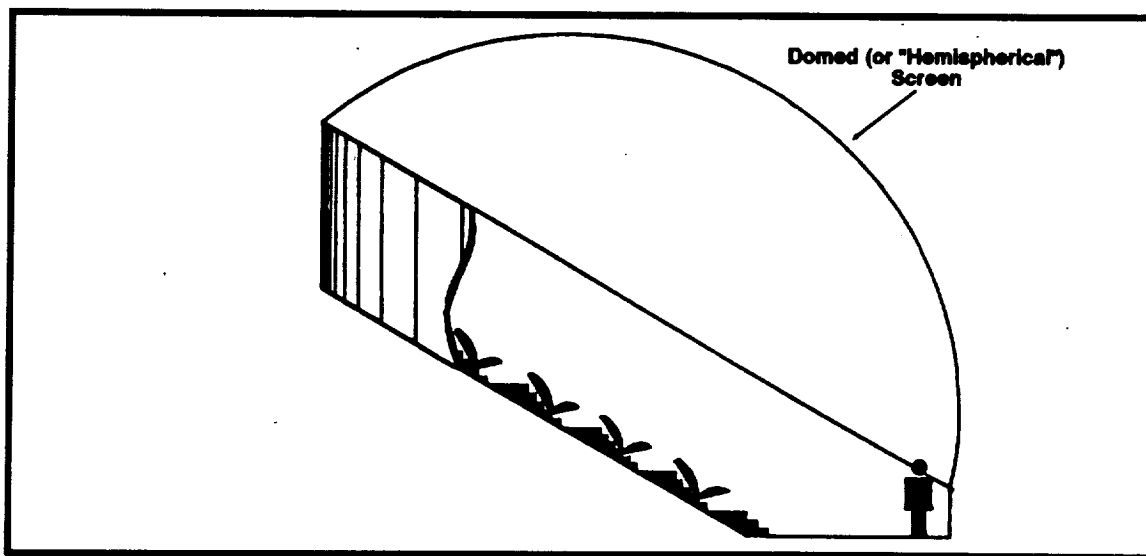


Fig. 2: Approximate Configuration of Omnimax Theatre

solutions, a very expensive, time-consuming and hazardous method of erecting scaffolding and hand cleaning the screens would be necessary.

It is indicated that a product solving this problem would be immediately purchased by the estimated one to two dozen theatres in operation in the U.S.

III. Technology Requirements:

Ben Millard of the Chicago Science Museum's OmniMax Theater is interested in deployable structures technology as a potential solution. Envisioned is a tripod-like device using extensible/retractable legs. The bases of the legs would be located at the edge of the screen, 120 degrees apart. Motor controllers, operated by a personal computer, would rotate and extend the legs so that a vacuum device at the tip could follow a coordinated path along the surface of the hemisphere (See Figure 3). The device should reach every point on the surface located above a man's reach of about eight feet. Ideally, such a system would be automatic so that it could operate overnight. The tripod legs should be fully retractable for ease of setting-up, dismantling, and storage.

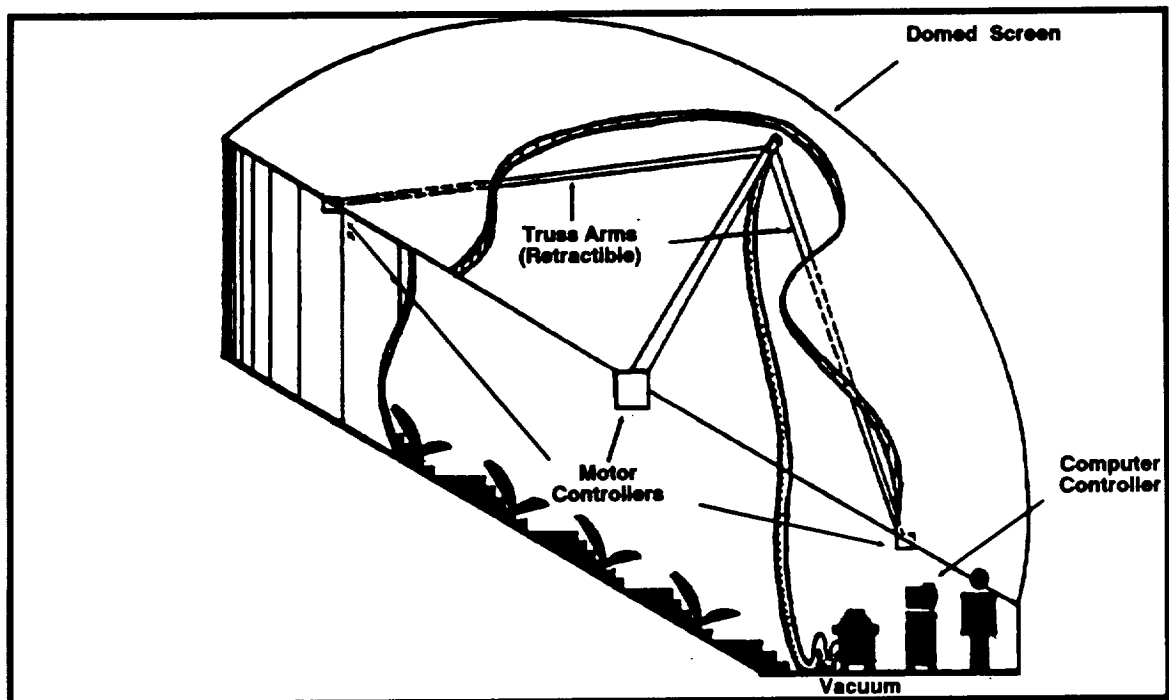


Fig. 3: Configuration of Truss-Based Cleaning Mechanism

Obviously, such technology could be employed in many other applications such as cleaning, maintenance and painting in shopping malls, indoor stadia or building lobbies with elevated ceilings, in high-rise construction, tree cutting, and power line maintenance.

IV. NASA Technology

NASA has been involved with the use of deployable structures for on-orbit and extended mission antennas, solar arrays, structural trusses, and robotic arms. It is believed that a cassette-type drive truss was installed in the NASA Hubble telescope system, such that the arm will retract "infinitely" around a spool similar to a retractable tape measure. Also of interest is the technology used for telescoping robot arm on the Viking Lander. The RTI Team has found a few recent concepts, mostly by the NASA Langley Research Center that have been briefly described in the NASA Tech Briefs, and included as illustrations following the Problem Statement.

V. Status and Recommended Action:

The RTI Team has received additional problem details and illustrations from the Chicago Science Museum. The Problem Statement has been forwarded to NASA Centers through their Technology Utilization Offices. The Team has contacted LaRC experts working on deployable structures. In the next quarter, a response will be sought from CSM on the specified NASA techniques and a meeting at a NASA Center arranged, if appropriate.

Problem Title: Improved Technologies for Kuwait Oil Well Control

Date of Preparation: March 21, 1991

Source of Problem: International Inferno Snuffers, San Antonio, TX

RTI Team Personnel: John Cleland, Robert Wallace, Jeff Antley

I. Technology Requirement

Improved methods of extinguishing and capping uncontrolled oil well heads are needed.

II. Background

A. Problem and Impact of the Solution:

Approximately six hundred oil wells were left burning after the Iraqi army's retreat from Kuwait in February 1991. Extinguishing fires and putting well-heads back into operating condition is expected to require two to five years. There are few burning wells which could be considered "typical" with regards to the best method of suppression. The condition of each wellhead must be assessed before the fire can be safely extinguished and the flow of oil stopped. In some cases the fires are too large or are too deep within the well to assess. In addition, limited equipment and manpower resources frustrate current attempts to subdue these fires. Established firefighting businesses currently operating in the Kuwaiti oil fields prefer their own proven methods. However, companies willing to invest in developmental firefighting technologies stand ready to replace them if conventional procedures prove to be too ineffective.

B. State of the Art:

Extinguishing a burning well is the initial concern. The method of choice usually depends on the size and condition of the fire. Some fires are quenched with a simple mixture of water and nitrogen. Makeshift inerting systems are also used which require the wellhead be contained by a piping network into which nitrogen can be pumped.

Before the oil well fire is addressed directly the area around the well-head is usually cooled down using thousands of gallons of water which may have to be pumped from the sea. After a site is cooled, a typical technique for attacking a Kuwaiti well fire is to use a Caterpillar or other tractor equipped with a heat shield made of welded corrugated tin. The tractor also pushes a special arm mounted on a miniature tank tread called an Anthey Wagon. At the end of the arm a hook may be mounted for chip away mounds of half-burned oil, or coke, that cakes around the well-head. Earth movers may be used to spread sand over surrounding pools of burning oil.

To extinguish the well fire, a firefighter driving a tractor moves a large explosive charge into place with the extendable arm, places the charge near the flame, jumps off and runs while the ensuing detonation robs the fire of oxygen and "blows out" the flame. Boots and Coots, a Houston-based company proposes to try injecting nitrogen into the fire through a large cylinder attached to a large bulldozer, while spraying water at the base of the cylinder. Alternatively, if the well fire is underground, a new well may be drilled to redirect the oil or cut it off.

Once the fire is extinguished, the wellhead and surrounding areas must be kept cool to prevent re-ignition. The structures and even the surrounding sand can reach temperatures of several hundred degrees Fahrenheit, which could ignite the spouting oil. Currently, these areas are sprayed with water and nitrogen to maintain a lowered temperature. Finally, the flow of oil must be stopped. Several methods of capping wild wellheads are available, depending on the condition of the head itself; any method must be successful despite the rush of oil and gases which can reach several thousand psi. In addition, the surrounding sand, which has sometimes turned to glass from the heat, may need to be cleared away in order to work on the well casing. Undamaged wellheads, or those with simple openings, can be controlled by pumping fluid (water or mud) into the well. Blowout protectors can also be attached to the casing. Split wellheads require more attention. To control a split wellhead, the earth around the head must be excavated to a point below the split. The damaged wellhead must be cut off, and the flow of oil can then be stopped as above. Methods of shearing off damaged wellheads include placing charges around the pipe to cut it, sawing the pipe off using high-strength steel wire, or using a high-pressure waterjet cutting system.

Sawing well pipes with steel wire can take as long as five days, while waterjet cutters need as little as an hour. Radio control of charges is limited in this instance because of the danger of detonating unlocated military explosives in close proximity.

III. Technical Requirements

Fighting blowouts is not a precise art. Technologies for controlling wellheads must be sturdy, foolproof, readily available, and cost effective. A typical Kuwaiti well fire is consuming \$100,000 to \$200,000 per day. The daily rate for a single firefighting team, including equipment operation and maintenance and other overhead, can be \$17,000 per day or \$1M per month. Therefore, cost is not a severe limitation in applying new technology. Time is more significant in the Kuwaiti situation, because rapid response is needed. Therefore, improvements should be able to be implemented within 6 months in order to be considered for application in Kuwait. On the other hand, longer term, safer, and cost-saving solutions are needed for the disasters that are certain to occur in the future.

The Department of Energy and the Union of Concerned Scientists have already held restricted meetings on the Kuwaiti problems. New technology approaches discussed but not yet implemented have included huge concrete domes for smothering fires, robots spraying dry chemicals or super-cold foams, water for fire-fighting pumped from beneath the oil wells themselves, and water jets or annular shaped charges for precisely cutting off well heads.

Among the available resources is liquid nitrogen. However, limited quantities allow its use only in inerting systems and not as a refrigerant for the heat shielding of large areas.

IV. NASA Technology

NASA engineers at Langley Research Center have expressed an interest in providing liquid nitrogen handling and inerting technologies for use in fire suppression. Liquid nitrogen may also be used to freeze substances through the use of an "ice patch"; the same technology used to freeze up holes in a spouting oil well could also be used to patch holes in leaking oil tankers. NASA has considerable experience in the efficient use of inert cryogenics and may be able to provide either system designs or consulting or both to new fire-fighting techniques. Another possibility is the utilization of NASA expertise in the design and implementation of large turbo- pumps, for cryogenics or water. Such capability has already been transferred by the NASA Marshall Space Flight Center to conventional and ship-board fire-fighting where considerable volumes of water must be pumped.

Status and Proposed Action

The RTI Applications Team has consulted with Mr. Tay Bond of Inferno Snuffers and with the consulting firm of O'Brien, Goins & Simpson, Inc. (Midland, TX), who are coordinating oil-well firefighting in Kuwait. The team has talked with interested researchers at LaRC and KSC. Attempts were made to arrange a meeting between NASA participants and private sector interests to put NASA ideas on the table and obtain an initial consensus of industry response. A favorable response would have been followed with an immediate Project Plan for early testing and implementation of the best technology concepts. However, T.B. O'Brien and associates indicated that nothing substantive could be accomplished in the near term by a meeting. The fire fighting teams seem to be satisfied with their methods and progress. A package of information on the current technology transfer options and status was mailed to interested parties.

**Problem Title: Reconfigurable Modular Manipulator System
(RMMS)**

Source of Problem: Dr. Pradeep Khosla, Director, Advanced Manipulator
Laboratory Robotics Institute, Carnegie Mellon University

RTI Team Personnel: Dean Hering

Background

This project was submitted by Dr. Pradeep Khosla at Carnegie Mellon University's Robotics Institute. With funding from NASA Goddard Space Flight Center and the Department of Energy, Dr. Khosla's Laboratory has developed an extremely flexible robotic manipulator which uses a stock of interchangeable joint and link modules which may be interconnected to meet a user requirement. The controlling and interface software are automatically updated, freeing the operator from tedious calculations or knowledge other than desired workspace specifications. This flexible design provides significant advantages over conventional fixed designs including portability, adaptability and modification, ease of repair, and economy of manufacture.

The RMMS potentially impacts the hazardous waste, flexible manufacturing, construction, and space industries.

Status

The RTI Team met with Dr. Khosla to review the technology and discuss potential markets. Representatives from the GSFC TU Office and Robotics Branch, the Department of Energy, the RTI Team, and Dr. Khosla then met at GSFC to determine the best strategy for transferring the RMMS to U.S. industry.

Based on material from Dr. Khosla and industry sources, the RTI Team developed a RMMS Prospectus. The Prospectus is used to provide information in following up with industry contacts, at conferences such as Technology 2000 and other industry meetings, and as a general purpose information source for interested industry and other agency representatives.

The Team has contacted engineers and managers in government, utilities, hazardous waste, flexible manufacturing, robotic manipulator manufacturers and integrators, automated systems, and other related industries to promote the RMMS. Additional potential partners have been identified and are being contacted.

Problem Title: Sprayed Zinc Coatings for Corrosion Control of Reinforcing Steel in Bridges

Date of Preparation: March 27, 1991
Problem Originator: Florida Department of Transportation
RTI Team Personnel: Stephen A. Lehrman

Technology Requirement:

A low cost method of spraying zinc galvanic coatings on reinforcing steel in bridges is required to control saltwater corrosion.

Background:

The Florida Department of Transportation and the University of South Florida are performing a one year research project for the Strategic Highway Research Program. The purpose of this project is to investigate using sprayed zinc coatings to control corrosion of reinforcing steel in marine bridges. The following problem description is taken from the Florida DoT and University of South Florida proposal Project Summary.

"Severe corrosion of reinforcing steel is often observed in the substructure of marine highway structures. The damage results from steel depassivation by chloride ions, especially where they are concentrated by evaporation of seawater. Corrosion products cause spalling of the concrete cover, which requires expensive repairs sometimes after only a few years of service. Current repair practice is frequently inadequate to prevent repeated deterioration. Positive protection by means of impressed current cathodic protection is costly and difficult to implement in the splash zone environment.

A novel concept using sprayed-zinc galvanic anodes is proposed for testing and development as a low-cost method of controlling reinforcement corrosion in marine substructures. The deteriorated components are blasted clean and arc-sprayed zinc is deposited directly over the exposed clean rebar and surrounding external concrete surface. The procedure creates reliable electrical contact with the steel, and provides a large area of contact between the anode and the underlying concrete. The appreciable concrete conductivity existing in typically humid marine substructure permits significant current delivery by the action of the unaided galvanic couple. The simple, two-step procedure is applicable

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to both regular and epoxy-coated rebar, avoiding cumbersome individual electrical connections in the latter case.

The concept represents a new approach in that 1) it uses a spray metal anode and does not require impressed current; 2) it is applied directly on spalled components without the need of concrete overlay and 3) the resulting costs are substantially lower than those of alternative repair of protection methods.

Limited trials of the concept by the Florida Department of Transportation have been highly encouraging. However, accurate information on the capabilities of the method is not available."

Technical Requirements:

The Florida DoT and University of South Florida project will investigate three tasks. These tasks are:

Task 1: Determine the limits of the ability of deposited zinc anodes to provide the required levels of current protection.

Task 2: Determine the effect of service and application parameters on the durability of the sprayed zinc anodes.

Task 3: Establish applicability of the method under field conditions.

NASA Technology:

Kennedy Space Center has performed extensive testing using zinc based coatings to control corrosion on steel structures at KSC. The Florida DoT and University of South Florida would benefit in performing the above tasks by KSC sharing their experimental data and providing technical assistance.

Participants:

- Mr. Rodney Powers, Florida Department of Transportation
- Dr. Alberto Sagues, University of South Florida

References:

1. Research Proposal titled "Low-Cost Sprayed Zinc Galvanic Anode For Control of Corrosion of Reinforcing Steel in Marine Bridge Substructures" by Powers and Sagues, submitted to the Strategic Highway Research Program.

Problem Title: Braille Devices to Allow Media Access

Date of Preparation: June 28, 1991
Source of Problem: Science Applications International Corp.
U. S. Department of Education
RTI Team Personnel: Daniel L. Winfield

I. Technology Requirement:

Technologies are required to develop miniature actuators for a low cost, high density, refreshable Braille display to aid media and computer communications access by persons with severe visual impairments.

II. Background:**A. Problem and Impact of Solution**

Electronic encoding and storage of data is now an established capability for braille information, as is the distribution system for recorded media and/or electronic media. However, persons who rely upon Braille have limited access to computer information due to the limited capability of existing Braille output devices to 40 to 80 characters. Although voice technology has made an impact on access, it does not allow the user to review material as it appears on the monitor or printed page to include format and structure.

Actuators used in present electronic Braille displays are either solenoid or piezoelectric reed electromechanical actuators. Problems result from the facts that these actuators cannot be packed closely enough to produce full screen displays of a useful size and the cost per character are excessive.

With the advent of large CD-ROM database libraries containing millions of print characters, the blind need Braille displays that allow them complete access to the information displayed on the computer monitor. A Braille display is needed that has the capability to generate the Braille equivalent of the computer screen. The best Braille displays now available limits persons with vision impairments to perceiving a single or double line of twenty, forty or, at most eighty Braille characters. This, of course, makes it difficult if not impossible to scan through text files looking for headings or jumping from paragraph to paragraph. There is a need for larger Braille displays to allow blind individuals to be empowered with the benefits of an information access capability equivalent to that of sighted persons for text. However, cost must remain an overriding consideration so that the devices are affordable to those in need.

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Over 100,000 persons with vision impairments use Braille to communicate and could benefit from improved, refreshable braille displays. This advanced Braille technology will offer the potential for dramatic improvements in telecommunications access for persons with sensory impairments directly from their existing computers as follows:

- Access to databases
- Access to electronic mail systems
- Access to bulletin board systems
- Access to mail order systems.

B. State of the Art

Louis Braille published a dot system of Braille in 1829 based on a "cell" of six dots. Braille defined the alphabet, punctuation marks, numerals, and later, a system for music using the 63 possible dot arrangements. Braille is read by running ones finger over a character and feeling the raised dot pattern. Braille devices used today include a Braillewriter, stylus on a pocket sized metal or plastic slate, Perkins Brailier, and computer Braille device.

The Perkins Brailier is capable of embossing twenty-five lines of forty characters each and has become the defacto standard within the industry. Because the Perkins Brailier page layout has been used for over 50 years, it is regarded by many as the most desirable page size. The necessity for margins all around dictate a page size of eleven by eleven inches.

The U.S. Department of Education has funded Braille device research and development over the past 20 years. With the advent of personal computers in 1975, the Department of Education began to fund research and development of computer Braille output devices such as the TeleBrailier, and microBrailier. Presently, the development of a Braille capability is a stated research priority of the U.S. Department of Education.

Refreshable braille displays was the subject of a problem statement distributed to NASA in January 1984 (copy attached for reference). While there were numerous responses, including development of a braille mouse, none solved the problem as presented, i.e., a full page, refreshable display. Also, no solution has been forthcoming from industry. No low cost, commercially available refreshable braille displays now exist.

Devices with refreshable braille displays use movable metal or plastic pins for the "dots." The heights of the pins are switched electrically through a form of electromechanical actuator controlled by inputs from the computer, magnetic recording media or optical scanner. The key limitations for refreshable braille

displays are the cost and size of the electromechanical mechanisms. Solution of this problem must focus on the actuator method to temporarily produce raised bumps (6000 or more per page). This new actuation method must allow sufficiently dense packing while having low power requirements and low costs.

The best refreshable displays (produced in this country) use piezoelectric reeds that flex in the presence of an electromotive force. Current state-of-the-art limits refreshable displays to two lines. In addition, the process for producing the Braille cells is an expensive labor intensive process. Current products are priced in the \$15,000 range, most of which can be attributed to the cost of the pin actuators and control. A comparable computer product containing a speech synthesizer for output (rather than braille display) is priced under \$1,000. The total cost of refreshable braille display products is generally between \$20 and \$25 per display dot. Manufacturers have stated a goal of securing technology to allow production with costs under \$1 per dot.

The mechanism to produce a line of 40 cell braille should have the capability of simultaneously controlling 240 pin positions for 6 dot braille. A more advanced system would need to control 640 pin positions per line of 80 character, 8 dot braille (8 dots allow representation of all 256 ASCII characters). Refresh rate would optimally be a few milliseconds.

The technology used in commercial devices is based on electromechanical actuation using solenoids or piezoelectrics. With these systems, the dot driving mechanisms are normally two or more times larger than the braille cell. Attempts have been made to utilize shape memory alloys. Likewise, efforts have been made to employ a rolling actuator similar to a dot matrix printer; but no commercial systems exist using either of these technologies.

III. Technology Constraints and Specifications:

The technical challenge is to design and construct a device that will reconfigure the moving pattern of a minimum of 240 pins per line in a fraction of a second. The technique should be applicable to a 640 pin display for 80 characters per line. The mechanism must be inexpensive, and the process reliable. The technique will ideally lend itself to a multiline display, optimally 25 lines within an 8"x10" footprint.

The technical problems confronting us at the moment should confine our attention to identifying a fresh approach to producing the dots required to form the Braille characters within the space limitations imposed by the following Braille specifications:

- Dot height 0.025 inch;
- Separation of dots within the Braille cell 0.083 inch; (0.090 inch acceptable);

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- Separation between dot four of a Braille cell from dot one of the next character following on the line 0.150 inch;
- Distance between dot one of a Braille cell and dot one of a cell on a line above or below 0.400 inch.

As mentioned earlier, cost is a significant factor, and the goal is to achieve a cost per dot of \$1.00. Other requirements include high reliability, rapid refresh rate, quiet and safe operation, and adaptability to a variety of inputs (computer, mag tape, CD, etc.)

Emerging technologies worthy of consideration include use of superconducting materials in miniature solenoids, micromechanical actuators, contractile polymers, and opto-mechanical means, e.g. laser scanning. Large array controllers for liquid crystal display can control 64 high voltage lines (i.e. 120-180 volts direct current (VDC)) from a single chip. Perhaps these controllers could be used to control 10 piezoelectric Braille cells. Other controllers are available that could control 20 or more elements.

Another promising technology is polymer gels that contract under the application of light and other input. By applying laser light or electronic stimulus to the polymer arranged in a Braille matrix it may be possible to implement a full page Braille device in a small light weight device.

Problem Title: Durability and Reliability of Externally Powered Elbow Prostheses

Date of Preparation: April 25, 1991

Source of Problem: National Easter Seal Society

RTI Team Personnel: Daniel L. Winfield

I. Technology Requirement:

Materials selection and innovative mechanical design are required to build more durable and reliable elbow joints for externally powered prostheses while maintaining cost at or below current levels.

II. Background:

A. Problem and Impact of Solution

The user of an upper extremity prosthesis relies upon the device to function in a wide range of daily activity in a variety of environments which place considerable demand upon the prosthetic components. The durability and reliability of the elbow joint unit is critical to the function of the externally powered prosthesis (i.e. a prosthesis powered and controlled by body harness and cable mechanism).

The elbow units are currently manufactured primarily from aluminum or stainless steel, and they do not meet operational criteria of vigorous users. There is a need to develop an elbow unit that is more durable and reliable in mechanical operation and free from component failure. New materials and mechanism design are needed to produce an improved elbow that will provide the user needed function and a balance of its strength to weight ratio.

The need for developing this technology is supported by clinical findings and the reporting of users in rural and industrial work settings. These users have usually lost their limb in such settings and want to return with the greatest level of function possible.

There are 40,000 above elbow amputees in the United States. As daily users of upper extremity prostheses, they may choose to use a powered limb with micro electronic or electro-magnetic control for light duty. But for heavy vigorous use, they choose the more widely accepted, cable-driven, body-powered prosthesis. Current cost for basic cable-driven, upper extremity prosthesis ranges between \$3,000 - \$7,000. Hybrid limbs (combined body powered and electric) are customized and tailored to users functional criteria and may cost in the range of \$9,000 - \$10,000.

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Clinical estimates indicate that the prosthetic limb life is 5 years if used daily. Over the 5 year period, an additional 10% of the original cost is necessary to maintain the prosthesis with replacement parts. The simple hinge elbow joint is the most frequently replaced component because of wear or component failure.

The elbow joint itself is a simple hinge in function, and the elbow of the prosthesis needs to be designed to operate as nearly as possible within the anatomical range of motion. There is a need to increase the load carrying capacity of the prosthesis with the elbow remaining in a locked position. This will require an improved elbow lock that can be positioned and locked in a wide range of user determined pre-set elbow angles.

Each prosthesis is custom fit to the user's stump and the components are integrated into limb segments that are proportional to the user's anatomical dimensions. Therefore the distance from elbow axis to the center of hand grip, and the elbow angle determines the moment the elbow mechanism must sustain.

Environmental conditions specific to rural, agricultural or industrial settings often interfere with the reliable operation and result in accelerated wear. When dirt gets into the mechanism, such as the grooves of the cam lock of the elbow unit, the locking bar may not completely drop into the detent, thus creating the potential of an accidental release.

B. State of the Art

The upper extremity prosthetic user may engage in a wide range of functional usage. The activities of the day start with performing personal care, feeding, driving to work, functioning at a desk, or operating machinery and tools in an industrial or farming setting. Hence, the upper arm amputee requires a light weight, durable, cosmetically-accepted prosthesis that provides reliability, versatility, and safety in its use. Some users will select an upper extremity prosthesis which has interchangeable terminal devices that accommodate or provide unique interfaces to the work environment.

The range of activities a person is capable of performing and the forces applied are dependant upon the interactive function of the body harness. This mechanism transmits force through external cables and hardware to control the elbow position and locking mechanism as well as the terminal device.

The consensus among users and clinicians is that the prosthetic elbow joint is currently the weakest link in the system. The two basic designs and their limitations are:

1. **Friction elbow** - is constructed from aluminum with plastic linings and the covering of the bushings being made of oilite and Teflon. In a

rural setting the elbow sprocket teeth (Figure #1, illustration E-63) tend to break causing an accidental release, or there is slippage when the terminal device is loaded such as when a farmer picks up a seed bag weighing up to 50 pounds.

One solution designed by a user has been to apply an external lock device to the elbow with a push button release operated with the opposing other hand. It is reported that a farmer's elbow sprocket teeth can break out of the 11 detent locking mechanism (Figure #1, illustration E-63 and Figure #2, illustration #39) just after 6 months of daily use. The mechanism is not reliable.

In one design an adjustable coil spring in the elbow unit (Figure #1, illustration E-460-9) is used for controlling the lock and changing forearm position while aligning the terminal device. The twisting motion to set this alignment is manually operated by the other hand. It is reported that through continued usage the tensile strength of the coil spring deteriorates and contributes to the accidental release of the elbow lock mechanism when the terminal device is heavily loaded.

2. Standard Elbow - has a heavy duty gear assembly fabricated from stainless steel. Stainless steel is strong and durable but in a rural or industrial setting, dirt in the mechanism, temperature, and incidental environment factors significantly alter function and reliability.

Our efforts to gain specific information and more clarity on design and materials from the manufacturers have not been productive because manufacturers consider this information classified or of proprietary nature. In our discussions with clinicians and manufacturers regarding new products and replacement parts, they have referred us to the widely accepted "Hosmer Dorrance Corporation" Catalogs, 10th edition (copyright 1983) and 11th edition (copyright 1986). The E-400 Elbow joint is referenced as a "rugged, functional elbow that may be used when performing ordinary tasks". The differences identified with the E-400 and E-400 HD are the use of a gear sector with either eleven or nine positive locking positions. Included in the E-400 HD model is a heavy duty cable, saddle, gear sector and internal assembly with the additional 15 ounce weight factor. We have included pages U-28, U-29 and U-34 from the Hosmer Dorrance 11th edition, and pages 104-106 from the 10th edition as reference illustrations from the catalogs.

III. Technology Constraints and Specifications:

NASA expertise is solicited for:

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Investigation and selection of

- a) Mechanical design of the elbow hinge unit and locking mechanism;
- b) Materials application; and
- c) Cost containment.

Optimization for

- a) Durability
- b) Prevention of failure
- c) Reliability - no accidental release of locking mechanism
- d) Activation of locking mechanism under loads and varying positions
- e) Balance strength to weight ratio

The functional specifications for the new technology, based on current research and development and reports from users are:

1. The elbow unit should out live the current 5 year life span.
 2. The elbow unit must lock and unlock under loads of 3-7 pounds.*
 3. The elbow unit must remain locked with loads of 18-20 pounds* on the prosthesis when the user pre-positions the humerus and changes the vertical and horizontal planes of movement. Body powered elbows must lock and unlock through the normal anatomical range of motion and remain locked going through full shoulder range.
- * No specific data exists on what these values should be. These are user estimates and are highly dependent on the anatomy of the individual's residual limb.
4. The weight of the mechanism must not unbalance the prosthesis.
 5. Replacement parts must remain within 10% of original unit cost.
 6. The elbow unit function must not be affected by environmental factors.
 7. Cost of the prosthesis should remain within \$3,000 - \$7,000.

Problem Title: Impending-Failure-Detection Expert System for Continuous Miner Motor/Hydraulic Subsystems

Date of Preparation: June 19, 1991

Source of Problem: Bruce McClellan, Joy Technologies, Inc.

RTI Team Personnel: Robert J. Wallace

I. Technology Requirement:

Embedded, real-time, expert-system software is needed to detect and alert machine operators of impending failures in the motor/hydraulic subsystems of continuous mining machines to avoid major production losses due to catastrophic machine failures in the coal cut.

II. Background

A. Problem and Impact of the Solution:

The cost of a total repair action on a continuous mining machine (CMM) is a function of where the machine fails, the parts of the machine that fail, the time the machine is unavailable for production, and the total labor charges of the maintenance personnel making the repair. A failure while a machine is in production results in compounded costs for downtime. Thus, any technique or technology that can help alert a mining operator to extract the CMM prior to a disabling machine failure will result in significant production cost savings. One means for alerting a machine operator to an impending failure in one of the machine's electric motors or hydraulic subsystems is an embedded machine health monitoring system. Such a system would incorporate multiple sensor networks and a fault monitoring hardware/software module running an Impending-Failure-Detection Expert System (IFDES).

The IFDES would go beyond the current practice in existing research systems to 'anticipate' failures before they occur rather than detect them only at the time they occur. This 'anticipatory' character of the impending failure detection design impacts the structure of the expert system, the knowledge base, and the selection of the inference engine design for this application.

Beyond the requirements for an anticipating expert system, a significant component of the impending failure detection system is the sensor network, and more specifically the sensors (e.g. accelerometers), that sample the vibrations or other phenomena that signal the first warnings of an impending breakdown. Many of the commercially available sensors that have been

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used in prior research on this problem have not held up to the harsh environment of continuous coal mining. New, more rugged sensors and sensor packages are needed as a critical enabling element of an overall NASA technical solution.

Another consideration in the specification and statement of this problem is the software architecture context in which the IFDES would reside. Failure detection logically resides within the 'safety' leg of a computerized system control software tree. That is, the fault detection function falls under a higher level general system safety function. In the context of the Martin Marietta/NASA Flight Telerobotic Servicer (FTS) software program, a system/subsystem 'health monitoring' function has been specified to watch for violations of range limits, torque overloads, and other violations of nominal ranges for various performance parameters. The manner in which this 'monitoring' function has been implemented within the overall FTS real-time control system (RCS) architecture using shared memory as a form of electronic blackboard provides a useful model for the corresponding function in a CMM IFDES.

B. State-of-the-Art

The application of embedded expert systems for detecting and reacting to failures and faults in computer controlled systems is several years old both at NASA and in industry at large. In many current prototype systems low level software that sits underneath the embedded expert system includes optimized signal processing/data reduction software that does most of the actual distillation of the critical impending failure information. An example of this specialized state-of-the-art software is the shaft synchronous averaging software for vibration monitoring of drive trains developed by Monitoring Technology Corporation (MTC) of Falls Church, Virginia. MTC's signal processing software represents a state-of-the-art capability to detect small defects in gears and bearings even in high background noise environments and is applicable to both on-board monitoring and preventive maintenance operations. In one use of this vibration monitoring technology the U.S. Air Force has been successful in detecting defects in the C-130 nose gearbox. In a similar monitoring application, small, non-critical defects were detected by a TRW/MTC-team in the roller elements of a bearing in a T-56 engine gearbox.

The state-of-the-art for computerized health monitoring of continuous mining machine subsystems is probably represented by existing diagnostic systems recently developed by the Pittsburgh Research Center of the U.S. Bureau of Mines. One such subsystem health monitoring system is an electric motor diagnostic system. This electric motor diagnostic system can simultaneous-

ly monitor, on-line the six motors on a Joy 16CM machine (see Figures 4 and 5). This state-of-the-art system derives a "figure of merit" proportional to the electrical resistance value of the insulation for each sensor-instrumented motor. The figure of merit is written to a data base and can be checked for trending over long intervals of time.

Fig. 4:

Information from the right-, left-, and master controller enclosures is sent to the electrical system diagnostic computer.

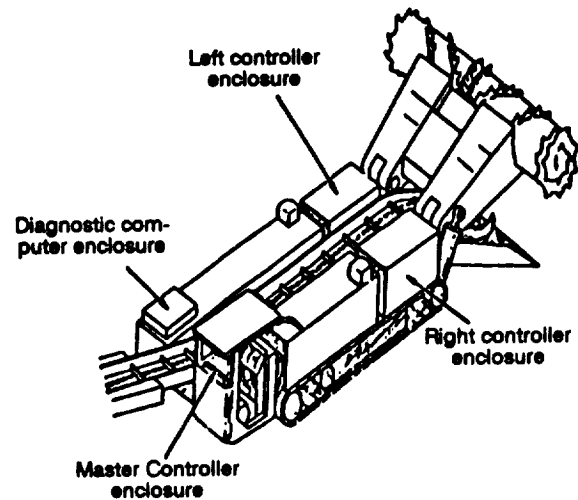
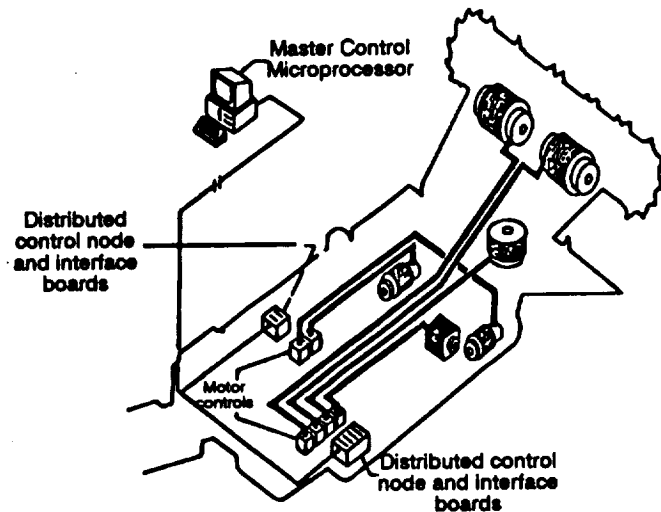


Fig. 5:

Information from six motors is collected by a distributed computer system, processed, and sent to a remote computer for analysis, reporting, and archiving.



Based on the current state-of-the-art for computer-based CMM health monitoring the next advance needed in this technology area is a higher level and more flexible embedded monitoring expert system technology such as that recently prototyped by NASA for some of its spacecraft systems.

The other critical enabling technology needed for a CMM IFDES is a rugged network of sensors, transducers and signal translation and communications equipment. Much of this technology is just recently available off-the-shelf as state-of-the-art technology from companies that supply embedded computer diagnostic technology for vibration monitoring of drive trains. One such system is available as an IBM-PC/AT

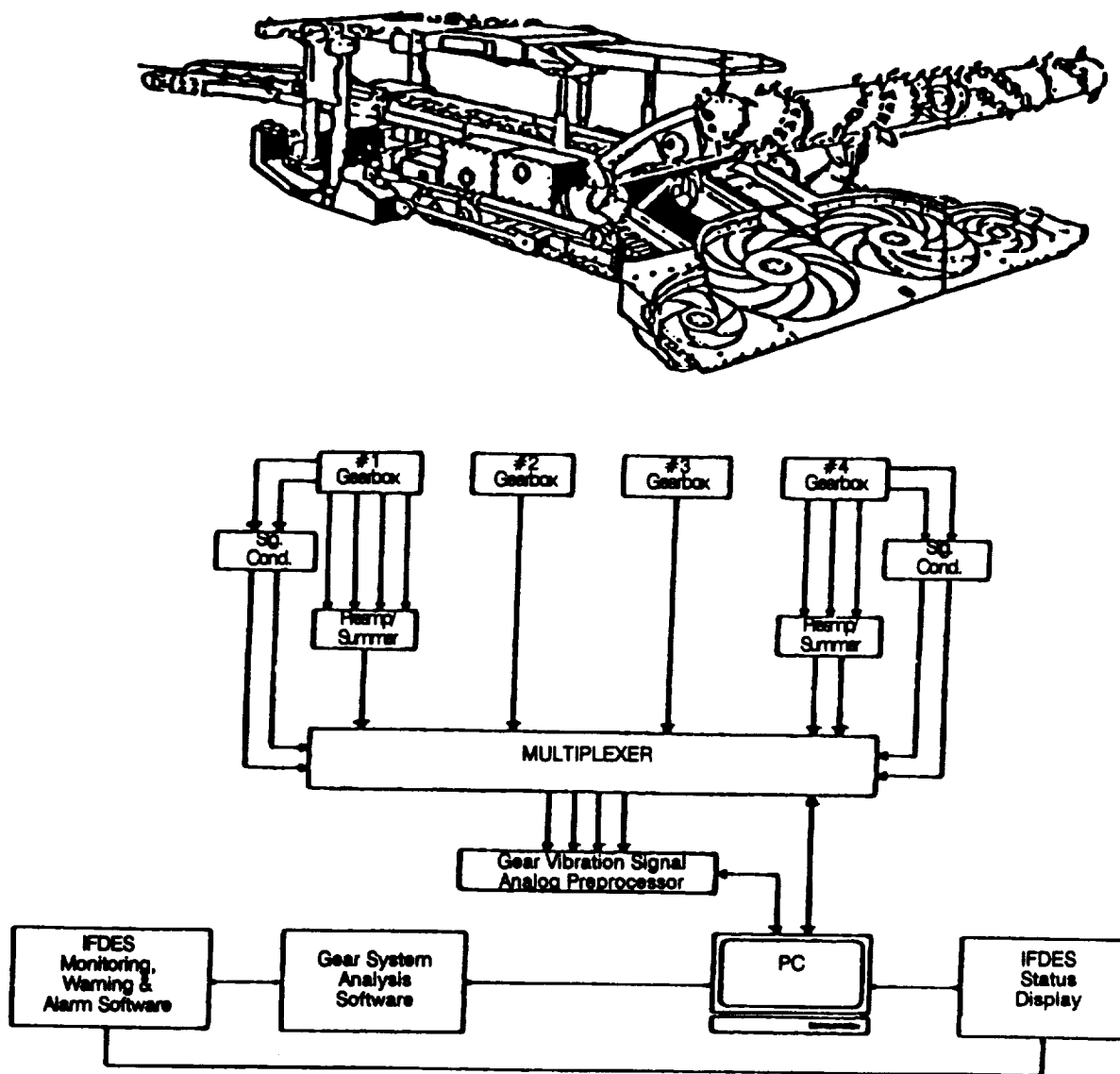


Fig. 6: Continuous Mining Machine IFDES Concept

personal computer add-in board, a sensor and electronics network along with gear system analysis software from MTC of Falls Church, Virginia. Figure 6 illustrates an IFDES concept for CMMs based on available components.

III. Technical Requirements

A need exists on the part of the U.S. continuous mining industry and the Control Systems Group at the U.S. Bureau of Mines for an Impending-Failure-Detection Expert System

(IFDES) for CMM motor/hydraulic subsystems. Typical parameters that can be monitored include fluid pressure, flow, temperature, level, and debris contamination for the hydraulic subsystem, insulation breakdown for the electric motor subsystem and bearing deterioration in motor gear trains. More specifically, IFDES technology needs include:

- Data driven situational displays
- Embedded computer-aided diagnostics
- Compatibility with and use of industry standards
- Data interface development utility
- User interface development utility
- Rule base development utility
- Consistent user interface 'look and feel'
- Mine environment rugged sensors and sensor network
- Compatibility with U.S. Bureau of Mine CMM automation architecture
- Multiple software module integration capability

IV. NASA Technology

A CMM IFDES could be based on or augmented by the NASA 'C' Language Integrated Production System (CLIPS) software product and the newly developed NASA Generic Spacecraft Analyst Assistant (GenSAA). GenSAA under development in the Automation Technology Section at NASA Goddard Space Flight Center (GSFC) will enable spacecraft analysts to easily build simple real-time expert systems for spacecraft monitoring and fault isolation functions. These embedded expert systems will assist spacecraft analysts during real-time operations activities in a variety of spacecraft payload control centers. The operational context in which GenSAA is to be applied is one where the spacecraft analyst must continuously monitor the current state of spacecraft operations as indicated by real-time telemetry parameters displayed on operations center consoles. The user interface component of the GenSAA will support both textual and graphical presentations of health and status information and fault isolation conclusions. Hypertext and hyper-graphic techniques will be supported to simplify operational interaction with GenSAA expert systems. The operational interaction is driven by three different types of data that are used by a GenSAA application during real-time operations: 1) Telemetry data; 2) Configuration data; 3) Inferred data.

Based on the capabilities of the current version of GenSAA this NASA technology has been identified as a candidate for prototyping, refining and making operational simple real-time expert systems for CMM motor/hydraulic subsystem monitoring and fault isolation. Combined with applicable sensor systems GenSAA is capable of providing the capabilities needed to implement a CMM IFDES.

V. Participants

- Bruce McClellan, Joy Technologies, Inc.
- Dr. George Schnakenberg, Jr., Control Systems Group, U.S. Bureau of Mines

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- William Stewart, U.S. Bureau of Mines, Mining Research
- Paul Hughes, Automation Technology Section, NASA/Goddard Space Flight Center
- Robert LaBaugh, FTS Flight Software Lead, Martin Marietta/Civil Space Systems
- Paul Haley, The Haley Enterprise

VI. Status and Recommended Action

The NASA GSFC Automation Technology Section's GenSAA software development product has been demonstrated as a first version in late spring 1991. The GenSAA product had been identified as a candidate software technology for developing real-time expert systems for CMM motor/hydraulic subsystem monitoring and fault isolation. The structure and attributes of this NASA software technology were presented by Peter Hughes of GSFC to engineers and researchers from Joy Technologies, the U.S. Bureau of Mines (USBM), members of the RTI Team, representatives from Martin Marietta (M-M) and the GSFC TUO. A general conclusion of the USBM staff was that the GenSAA software would likely offer a better fit with future phases of USBM work on central control console-based expert systems.

On the basis of general agreement among the participants at the meeting, a MOU for mutual technology transfer was signed by M-M, USBM, and GSFC in September 1991. The parties have initiated an informal study of a range of potential technology transfers from NASA GSFC and the M-M Flight Telerobotic Servicer (FTS) program. In the absence of a funded technology transfer project specific to the GSFC GenSAA software, it has been proposed that initial transfers will be accomplished through informal exchanges of software, information and, where possible, personnel.

Problem Title: Improved Telecommunication Technology for People Who Are Hearing Impaired

Date of Preparation: April 25, 1991
Source of Problem: National Easter Seal Society
RTI Team Personnel: Daniel L. Winfield

I. Technology Requirement:

Systems design, which includes improved automated speech recognition and telecommunication technology, is needed to significantly improve the ability of people who are deaf or hearing impaired to use telephone systems.

II. Background:

People who are deaf or hard of hearing are excluded from the use of voice transmission and recording technologies. These persons must rely on devices that provide visual or tactile representation of information. The equipment they currently use falls into several categories; telecommunication devices for the deaf (TDD's), computers, touchtone decoders and speech generating augmentative communication equipment. This equipment may allow them to use telecommunication systems, however, they remain restricted in this environment. Universal communication between the hearing and the deaf or hearing impaired is not available.

The challenge is to integrate recent and rapidly advancing technology in information processing and transmission to provide a cost effective method of emulating voice communication for these persons. The objective is to maximally integrate the person who is deaf or hearing impaired by providing universal access to telecommunications.

Development of telecommunication technology in this area has had a significant lag due primarily to socioeconomic factors. The user community was slow to accept or pursue change and there was a lack of funding to support a market and/or development of one. The majority of equipment in use is based on old technology that has been built upon in a rather piecemeal manner. The market is changing rapidly with greater awareness of the benefits of new technology and legislated accessibility. There is a great deal of activity which is addressing new technology and policy in this area.

It would appear that a NASA team could take a systems approach to the design of a system which would apply advanced information processing combined with

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information transmission technology. The objective is to incorporate the communication needs of people who are deaf or hard of hearing into the new telecommunication capabilities being developed for personal and business use.

The most critical link in the process of achieving the desired flexibility and integration is development of automated speech recognition. This capability can be combined with even the current methods of converting text to speech, to create a "translator" function. This technology would then need universal interface to standard telecommunication systems that include cellular phone, paging systems, and voice mail. Most of this capability needs to be available for both personal and business use, therefore the costs of equipment need to be realistic. The increasing utilization of voice messaging systems offers another major challenge in the business world.

State of the Art

One of the most replete sources for this section is a monograph titled "State of the Art: Visual Devices for Deaf and Hard of Hearing People", by Judith E. Harkin, Technology Assessment Program, Gaulladet Research Institute, Washington D.C. This person and institute are an excellent resource on this topic.

The most common visual device for the deaf person to use is a telecommunication device for the deaf (TDD). For direct communication, each partner must have such a device. The TDD is traditionally acoustically coupled through telephone handsets and transmit over landline and microwave systems, and, recently, cellular telephones. The older equipment uses Baudot version's transmission code, which is a 5 level code that transmits at 45.45 baud. There are a limited number of levels in Baudot code (5 binary bits) and the number of characters that can be generated in this code is small (32 total characters). The next level of transmission code, is ASCII 2, which is the standard 8 bit code for computer communication. Obviously, Baudot and ASCII 2 are incompatible. An advanced, standardized communication protocol needs to be established.

When both partners do not have a TDD, they use a relay station where a third person with a TDD performs the speech to visual, and visual to speech conversion that allows the hearing and non-hearing partners to communicate. This is very slow, and expensive. In a recent development paging systems have been used to offer the ability to transmit messages of up to 80 characters anywhere within a paging network. The paging is generated either from a voice or a TDD call to the central paging office which transmits to the paging receiver that will vibrate to notify the person of the incoming page and display an 80 character message on a palm sized receiver. Automating the function of the relay center would provide a significant improvement in access and cost.

Personal computers are being used as alternate TDD's with special software and connectivity. There are certainly recognized benefits of using a computer in the

communication link, and in the future it may be possible to perform the translation functions in a portable processor. There will certainly be an evolution in the use of these products for telecommunications in the future.

Touch tone decoding techniques have been developed to eliminate the need of the hearing person to have a special device in order to communicate with a deaf or hard of hearing person. The hearing person can use the touch tone pad of a telephone to tap out the message on the touch tone keys, and the hearing impaired person that is receiving uses a device which decodes the tones. This can be used bidirectionally if each person has a decoder but it has obvious drawbacks of limited rate and flexibility.

Video telephone technology has been proposed, however it does require that both partners in the conversation have expensive equipment. It allows exchange of visual images and the potential for individuals who sign to communicate through such a system. Current transmission rates of these telephone systems are barely adequate to provide the image quality necessary to transmit an intelligible signed image.

State of the art and national policy are being addressed by the National Telecommunications Policy Project at the World Institute on Disability; 510 16th Street, Oakland, CA, 94612; (415) 763-4100. The project director is Debbie Kaplan, PhD. The project has convened a Blue Ribbon Panel of national leaders.

The project is focused on regular meetings of a "Blue Ribbon Panel", which is composed of leaders of national disability organizations such as the American Council of the Blind, United Cerebral Palsy, the President's Committee on Employment of Persons with Disabilities, the National Council on Independent Living, Gallaudet University's Research Institute, Telecommunications for the Deaf, the Alliance for Technology Access, and Self-Help for Hard of Hearing People, among others. It meets bi-annually, in California and Washington, D.C.; the agendas include presentations about telecommunications and computer technology, applications for persons with disabilities, future potential products, legislative and regulatory initiatives, and dialogues with industry, consumer and legislative representatives.

The panel will produce two products: 1) a report on the demographics and needs of the diverse disabled community with respect to telecommunications products and services, and 2) a "white paper" with public policy recommendations for the industry, policy-makers, and disability organizations regarding the best approaches for the future. These reports are expected to be completed during the summer of 1991.

The state of the art in automated speech recognition is changing so rapidly that literature citations or most commercial applications are not the current references. Personal communication with researchers and developers indicates that current

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laboratory work is considerably ahead of what is evident in publications or the marketplace. Therefore, personal contacts and professional presentations offer far more current perspectives.

Jared Bernstein at SRI International is frequently verbally cited as a leading information source and he has provided good input to this project. The RESNA Special Interest Group 08: Sensory Aids is holding a Special Session on Telecommunications: Post ADA on June 25th, 1991 in Kansas City. The American Voice I/O Society is holding their 10th Annual Conference in Atlanta September 24-26, 1991. Commercial contacts in speech recognition have generally considered the discussion of specific technologies as proprietary information.

Commercial telecommunication technology is somewhat more stable in its rate of development, however a variety of proprietary activities among the equipment and service providers has produced a great deal of inconsistency in the technical approaches applied. Efforts are underway to standardize protocols and to interface the major systems.

Use of new paging (simulcast) and cellular (frequency re-use) technology for personal communications systems is showing promise. McCaw Communication has introduced a TDD Telemessaging paging services for people who are deaf and hard of hearing. The message is initiated by either a voice or TDD call to a relay or dispatching service which transmits to an alpha numeric information display pager. The display is 80 letters or numbers. Mark Schultz at Telepage/McCaw Communication is a good reference in this area.

III. Technology Constraints and Specifications:

NASA's expertise is solicited for:

Development of a system design that includes;

- Use of advanced information processing that would improve automated conversion of speech to text and text to speech.
- Digital information transmission technology, which interfaces the speech conversion process with commercial land line and radio frequency telecommunication operations.
- Cost containment of equipment and services to make it as available as possible.
- Equipment design for ease of operation by non-technical users.
- Equipment designed to maximize transfer of skills and technology to allow easy transition from current equipment.

**Problem Title: Man-Machine Interface Rapid Prototyping
Workstation for Continuous Mining Control
Consoles**

Date of Preparation: May 15, 1991

Source of Problem: Dr. George Schnakenberg, Jr., Control
Systems Group, U.S. Bureau of Mines

RTI Team Personnel: Robert J. Wallace

I. Technology Requirement:

A need exists to support rapid and flexible prototyping of the computer-based man-machine interface component of control consoles for future continuous mining control rooms.

II. Background

A. Problem and Impact of the Solution

A major research goal of the U.S. Bureau of Mines and the U.S. coal mining industry in general is the elimination of the need for human presence at the coal face during the most hazardous operations of modern room and pillar mining. The most hazardous of these operations are the extraction of coal using a continuous mining machine and the bolting of the unsupported roof shortly after coal cutting. Other associated tasks such as coal haulage, ventilation control, roof sounding, and methane testing, which occur in the same time interval and location, are also hazardous. As a consequence, coal face activities and the associated equipment are natural high priority targets for the application of automation and remote control technology. Of the various modern coal mining systems the technique called "deep cut mining" is particularly productive and appears to offer clear benefits for computer assisted tele-operated control of the continuous mining equipment fleet.

Deep cut mining is different from more conventional room and pillar mining in that the coal is extracted for a depth of 35 to 50 feet before the mining machine is withdrawn. This difference gives immediate rise to two major disadvantages of deep cut mining, 1) the inability of the machine operator to see the machine being controlled when it is deep into the cut and 2) the greatly extended area of unsupported roof which is more subject to falling during the roof bolting stage. If the continuous mining and bolting machines were tele-operated from a remote, secure control room using optimized, hybrid, man-machine operator consoles, then the coal could be extracted and the unsupported roof secured while minimizing operator exposure and risk.

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A proposed scenario for computer assisted, tele-operated control of a continuous mining suite of equipment (i.e. continuous miner, continuous haulage system and roof bolting system) envisions a comfortable control room to house operators close to the power center of the local mine section. Mining, hauling and bolting would be supervised by personnel in the control room who have television and other multi-sensor contact with each vehicle in the continuous mining equipment fleet. These control room personnel would also monitor machine performance and provide high level tasking or mission directives for translation into low level machine tasks or objectives. The actual detailed machine actions would be executed by lower level computer controllers. Figure 7 depicts a conceptualization of the tele-operated room and pillar mining scenario.

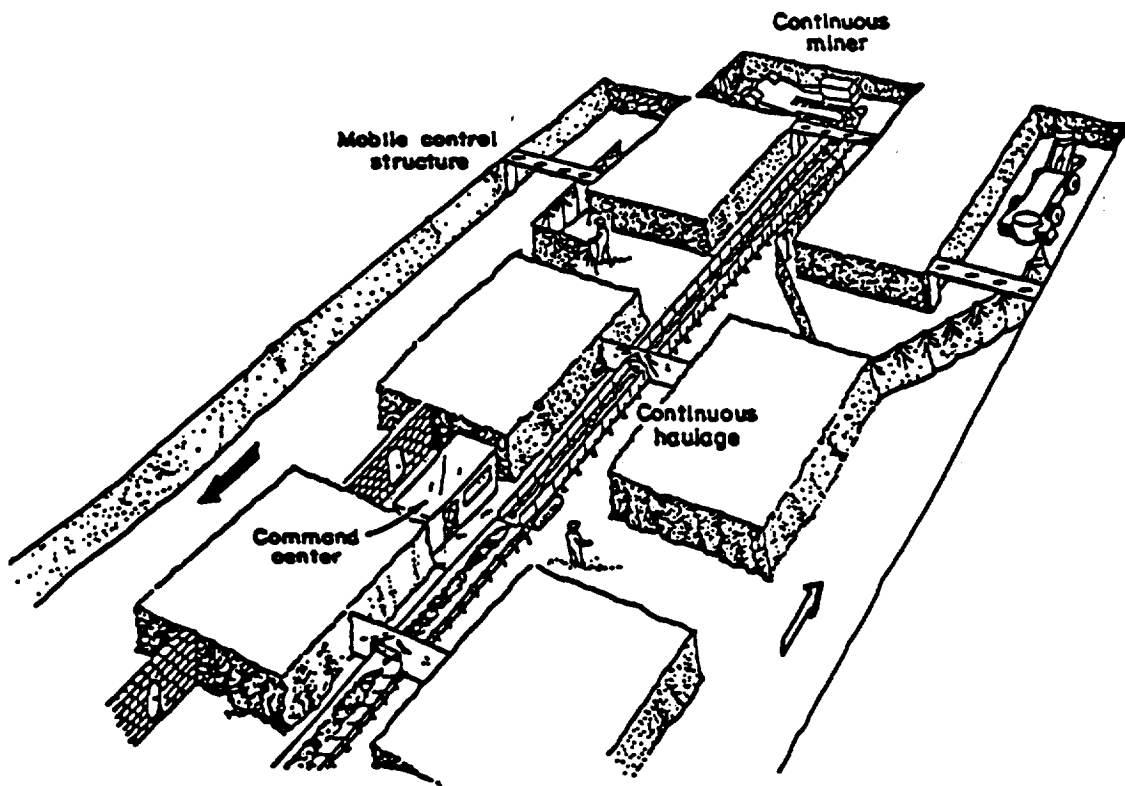


Fig. 7: Targeted room and pillar mining scenario concept

Among the enabling technology requirements which derive from the tele-operated room and pillar scenario are:

- Computer-based control systems.
- Computer-aided planning (goals, tasks, actions).
- Embedded diagnostics.
- Real-time control system architectures.

Each of these enabling technology requirements is addressed in some fashion by the Mining Automation Real-Time Control System Architecture Standard Reference Model (MASREM). MASREM was adapted by the National Institute of Standards and Technology (NIST) under the sponsorship of the U.S. Bureau of Mines, from the NIST Automated Manufacturing Research Facility (AMRF). MASREM defines a logical hierarchical architecture for mining automation derived from a number of concepts developed in earlier and on-going research programs such as the NIST/NASA Real-Time Control System Architecture Standard Reference Model (NASREM). The MASREM architecture defines a set of standard modules and interfaces which will facilitate mining automation software design, development, validation, and test. Predefined standard interfaces also provide the software hooks necessary to incrementally upgrade future mining automation systems as new capabilities develop.

As the FTS functional control architecture, NASREM encompasses the man-machine interface element which in turn incorporates the functional requirements for the tele-operation control console or workstation. This computer-based element is central to the semi-autonomous, manual override automation capability defined for the most advanced FTS configuration. These highly integrated, man-machine interface requirements have been highlighted as critical enabling technologies for next generation tele-operated room and pillar mining. If such technology elements were available today for U.S. continuous mining equipment manufacturers, the technology foundation that supports their international product competitiveness could be enhanced for the next 5-10 years. Furthermore, such product technology would gradually lead to increased American coal mining equipment sales as these productivity enhancing technologies are demonstrated in more and more operating coal mines.

B. State-of-the-Art

Remotely controlled continuous mining machines have been available for several years, with remote operator control using either a cabled or wireless control pendant. Recent research work by the industry and the Control Systems Group of the U.S. Bureau of Mines has explored more advanced forms of

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remote tele-operation for both the continuous mining machine and the other major equipment elements of the continuous mining vehicle fleet. A portion of this research examines the continuous mining control room which houses the man-machine tele-operation control console. Within the tele-operation control console system are simulation/simulator functions which support rapid prototyping of the continuous mining operator man-machine interface. Since the envisioned next generation room and pillar continuous mining system incorporates multiple television and other sensor inputs, the user interface portion of the tele-operation control console would ideally support touch screens, programmable display push buttons, live video with dynamic graphics overlays, data driven animated situational displays and speech recognition and synthesis. Such tele-operation control console technology has been demonstrated in the Martin Marietta FTS Prototype Simulator.

The Martin Marietta FTS Prototype Simulator was a contract deliverable to NASA JSC demonstrated in June 1990. The FTS Prototype Simulator was developed under contract to NASA to allow astronauts and other NASA personnel to evaluate the baseline design for the FTS Development Test Flight 1 (DTF-1) mission configuration. This Martin Marietta/NASA development represents a man-machine tele-operation control console development and test technology which is close to or in fact represents the current state-of-the-art in this developing area of technology.

III. NASA Technology

The Martin Marietta/NASA Flight Telerobotic Servicer Prototype Simulator represents a tele-operation control console approach which can be transferred to the U.S. next-generation room and pillar continuous mining system. This simulator, as delivered to meet NASA research needs, uniquely combines a manual hand controller, a rapid modeling capability for the user interface, a graphics work station for implementing a working "rapid simulator", and other tabletop components that allow users to conduct meaningful tele-operation control system analyses. The simulator software contains communications and executive software interacting with a highly realistic graphical representation of the Space Shuttle hard-wired FTS operator console panels and computer screens. On these simulator panels and computer screens the operator sees graphical representations of the FTS system through various camera views available to the operator in the real system. When the operator moves the hand controller, the robot arm moves and joint angles are displayed on the operator interface prototype. The configuration and a

functional diagram of the Martin Marietta/NASA FTS Prototype Simulator are shown in Figures 8 and 9.

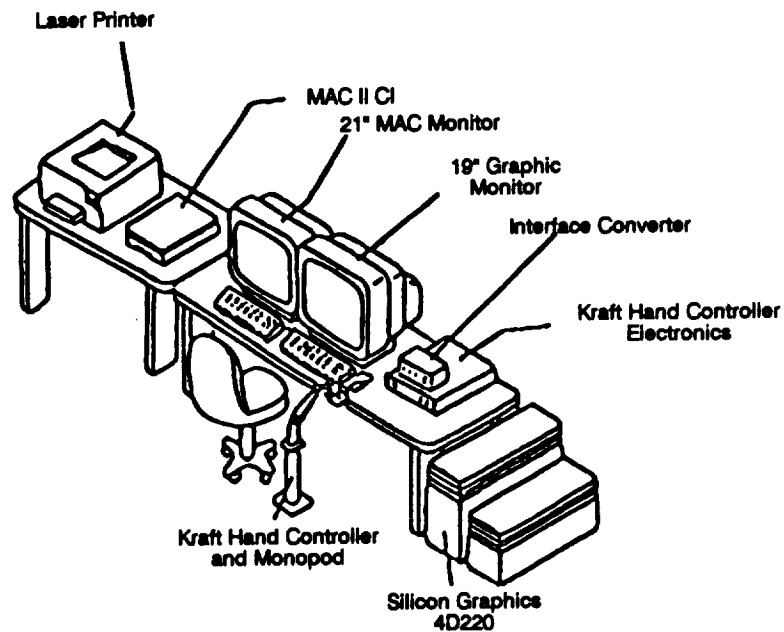


Fig. 8: DTF-1 Prototype Simulator Configuration

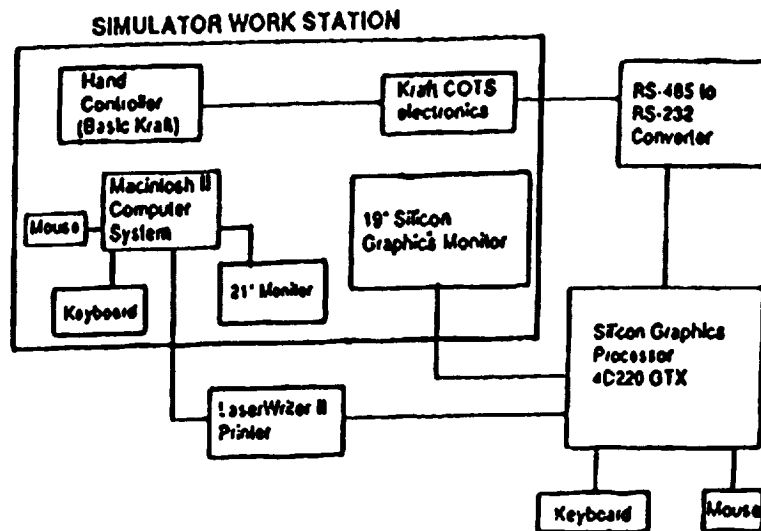


Fig. 9: DTF-1 Prototype Simulator Functional Block Diag.

IV. Technical Requirements

A need exists on the part of the U.S. continuous mining industry and the Control Systems Group at the U.S. Bureau of Mines for a man-machine interface rapid prototyping workstation for continuous mining control console research and development. More elemental continuous mining tele-operation control console technology needs are:

- Touch screen capability
- Programmable display pushbuttons/toggle switches
- Live video with dynamic graphics overlays
- Data driven animated situational displays
- Speech recognition and synthesis
- Real-time, multi-tasking operating system
- Flexible, commercial-off-the-shelf (COTS) networking capability
- Manual controller input capability
- Mission/task analysis knowledge/script capture software
- Real-time control system architecture
- Embedded computer-aided diagnostics

V. Participants

- Dr. George Schnakenberg, Jr., Control Systems Group, U.S. Bureau of Mines
- William Stewart, U.S. Bureau of Mines
- Craig Hartley, Civil Space Systems, Martin Marietta

VI. Status and Recommended Action

The Martin Marietta/NASA FTS Prototype Simulator has recently been returned to Martin Marietta in Denver, Colorado following FTS operator console analyses at NASA JSC. Additional control console modifications and visual feedback concepts for astronaut tele-operation have been further evaluated. Results from the tele-operation task analyses performed with the FTS Prototype Simulator have been fed into the design and current implementation of the operational FTS Trainer. The FTS Prototype Simulator program is drawing to a conclusion which should free up the system for studies of the feasibility of adapting the technology to rapid prototyping of continuous mining control consoles in conjunction with pending Bureau of Mines studies in this technology area.

This FTS technology has shown promise for meeting current and future control console R&D needs of the U.S. Bureau of Mines and U.S. continuous mining equipment manufacturers. A MOU has been signed by Martin Marietta, US Bureau of Mines, and GSFC. It has been proposed that technology transfers be accomplished through the exchanges of software information and personnel until the basis for a funded technology transfer project is established. With the cancellation of the FTS Program by NASA, the potential for transferring FTS technology such as the FTS Trainer is now the subject of a feasibility study by GSFC and Martin Marietta. This study will not be strictly limited to the Martin Marietta developed FTS Trainer. The possibility of establishing a formal technology transfer project based on this technology will be subject to the commitment of personnel and funding by the respective parties.

Problem Title: Monitoring and Life Support of Medically Fragile Children in the Educational Setting

Date of Preparation: April 16, 1991

Source of Problem: Center for Special Education Technology, Council
for Exceptional Children

RTI Team Personnel: Dean Hering

I. Technology Requirement

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

II. Background

A. Problem and Impact of Solution:

An increasing number of medically fragile children are in evidence in the public schools. Public Law 94-142, the Education for All Handicapped Children Act, and Section 504 of the Rehabilitation Act have provided access to classrooms to previously unserved students [1]. Furthermore, with recent improvements in medical technology it is possible to sustain the lives of many children who might previously have died. 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. Some sources estimate that as many as 100,000 infants and children may be in some way technologically dependent [2]. 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. The device needed should allow for the addition or removal of monitoring and life support systems as the needs of the child change.

Integrating these systems would reduce the number of single-purpose monitoring and life support systems needed by an individual child, significantly reducing the cost of patient care. Such a device would also reduce complexity of care and allow

care-providers who do not have medical training to care for medically fragile children with more confidence and independence. The alarms and warning systems could be reduced to an integrated alarm management system that would reduce the number and complexity of warning systems; the number of cables, tubes, and sensors could likewise be reduced.

B. State-of-the-Art:

The following is a listing of some of the electronic monitoring and life support systems most commonly found in public school classrooms and in the homes of children with multiple medical needs.

Life Support Systems:

Ventilators: Systems which breathe for a child who is unable to breathe independently. The device can be adjusted for breathing rate and volume of air pumped into the lungs. Alarms indicate when the device has failed to breathe for the child at rate indicated. Alarms also indicate when there is a blockage or break in the system.

Suctioning Devices: Systems which remove mucous or foreign items such as food from the airways of a child who is unable to clear airways independently.

Dialysis Machines: Systems which clean the blood of an individual whose kidneys do not function adequately.

Monitoring Systems:

Blood Level Monitors: Systems which monitor the level of medicine or particular chemicals in a child's blood. These devices are used when a child requires a consistent level of medication for survival.

Heart Rate and Blood Pressure Monitors: Systems which monitor the heart rate and/or blood pressure of a child whose heart does not function consistently. Alarms may sound when the child's heart fails to maintain adequate rate or pressure. Alarms may also sound when the device is not functioning properly.

Apnea Monitors: Systems which monitor breathing rate. These devices do not help the child breathe, but do sound an alarm when the individual fails to breathe independently.

Oxygen Saturation Monitors: Systems which monitor the amount of oxygen in the blood stream of a child. Alarms indicate times when the oxygen levels fall below acceptable norms.

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EKG Monitors: Systems which monitor the functioning of the heart muscles. These devices are usually worn on the body for diagnostic purposes.

Any one child may require several of these devices. Each device may have separate tubes, cabling system, power supply, alarm system and additional equipment or supplies. An individual child requiring the use of two or more systems may have several items attached to the body as well as individual extension cords or power supplies for each monitoring system. The use of multiple monitoring and life support systems, while supporting life, limits the individual's ability to participate in activities of daily living. For example, a child requiring oxygen and blood level monitoring may be as restricted by the weight and size of the life support systems as by the disability which necessitates the use of the systems.

A second complication resulting from multiple monitors and life supports is confusion on the part of care-providers. 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. Once the source of the problem is located, it is more difficult to remedy problems when multiple sensors and tubes are connected from the child to the monitoring devices. A system which integrates these sensors, the alarms and presents the information clearly to care-provider would greatly enhance the effectiveness of the equipment. Several leading medical monitor manufacturers indicate that alarm management and coherent instructions for care-providers via displays on monitoring systems are of great interest to their industry and would provide worthwhile opportunities in the medical monitor device market sector.

Finally, the use of multiple monitoring and life support systems is expensive. Individual devices may range from \$500 to \$5000. Current modular monitor systems exist in hospitals; however, such systems are too bulky, expensive, and unsuitable for portable use outside the hospital environment. The development of a multi-use monitoring system would reduce cost by limiting the number of devices an individual requires and by providing a single device which would be appropriate for a variety of users.

III. Technology Constraints and Specifications:

A modular monitoring and life support device is needed to integrate multiple monitoring and life support devices. Supervisory hardware and software must be included in a system which allows for the addition or removal of system modules depending on the immediate medical needs of the child.

The system should allow for the addition of options as needed by the individual user.

A single alarm management system should integrate the alarms for the individual devices to alert the care-provider to a problem and provide guidance via a visual readout. Instructions as to remedial action needed could be included in the display features. An integrated power distribution system might be also be considered.

Other technologies which may be able to contribute to the solution of this problem include light weight batteries, more efficient electronics to reduce power consumption, wireless telemetry to untether the child from the physical monitor system, human factors design of displays and control systems for clear, concise displays, common bus arrangements to facilitate plug in capabilities, hardware and software systems to control multiple alarm and control systems, and new technical methods to accomplish functions of the individual devices (e.g. a single blood monitor, more efficient breath circuits for ventilators) or to combine functions of two devices in a single module.

Physical dimensions and connecting sensors should be limited to the extent possible in order to make the device portable and less cumbersome. Weight is a critical factor and should be kept under ten pounds, including power supply, but excluding external oxygen tank (if present).

IV. Status

The Team initiated a new Technology Transfer effort with Susan Elting of the Center for Special Education Technology. Ms. Elting arranged a telephone conference call with eight special education technologists and practitioners from around the country, forming an expert panel to discuss industry problems that could benefit from the use of NASA technology. This conference call was followed by a meeting with Ms. Elting and representatives from JSC's Software Development Branch and Technology Utilization Office during Technology 2000. In a second teleconference, the Center for Special Education Technology expert panel and the Team identified three priority problem areas.

The Team then co-chaired a Special Session at the 1991 International Conference on Special Education and Technology in Kansas City in January. Session participants contributed to developing two of the areas which may be assisted using NASA technology. The panel and other participants discussed ideas relating to monitoring medically fragile children in the classroom and intelligent computer assisted tutoring. The Team additionally met with the problem area leaders to provide guidance in developing technical requirements.

The Team contacted five medical industry companies to determine the commercial interests and opinions on the medically fragile children monitoring problem area. Industry representatives indicated a positive interest in this problem area and their interests were incorporated in the problem statement. The team located several

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researchers at Field Centers who might provide expertise in solving the problems identified in the problem statement. These researchers were suggested to the Field Center TUOs with the submission of the Problem Statement. Two groups at Johnson Space Center responded with promising technologies in the problem areas. The Team organized a meeting in September at JSC with the special education problem statement task leader, JSC and KRUG (contractor) researchers, a hospital/biomedical advisor, the TU Office and the Team. The meeting participants developed ideas for applying the technologies and what type of corporate partner should the group should seek. One of the industry contributors to the problem statement was identified as a good corporate candidate. That potential partner was contacted and is interested. The Team is organizing a meeting in November at JSC to discuss a collaboration.

V. References

1. Sirvis, Barbara. "Students with Special Health Care Needs." Teaching Exceptional Children, The Council for Exceptional Children, Reston VA, Summer 1988.
2. The Council for Exceptional Children. Final Report by the CEC Ad Hoc Committee on Medically Fragile Students, Reston VA, March 1988.

Problem Title: Artificial Aurora Educational Museum Display

Source of Problem: Mr. William Parker, Light Age Tech Labs, Inc.

RTI Team Personnel: Dean Hering

Background

This project initiated during a telephone inquiry by Mr. William Parker, Director of Research at Light Age Tech Labs in Vermont, a company which designs, develops, and constructs scientifically accurate educational displays for museums and public displays around the world. In response to science museums in the United States and Canada, Light Age is developing an accurate artificial aurora display. Mr. Parker, an expert in plasma physics, contacted RTI to determine research areas at NASA that might assist in producing the most accurate current understanding of auroras.

Status

The Team contacted Dr. Thomas Moore, Branch Chief of Marshall Space Flight Center's Magnetospheric Physics Branch, to discuss his group's work in auroras. Determining that there was an excellent match with Dr. Moore's Branch and that his group was interested in assisting Light Age, RTI coordinated a teleconference between Mr. Parker, Dr. Moore and branch members, and the Team. Dr. Moore's group and Mr. Parker spoke at length about current research and technical ideas for generating an artificial aurora suitable for a museum display.

Based on the interest generated during the teleconference, RTI organized a meeting at Marshall for further discussion and a review of the Magnetospheric Branch laboratories. Dr. Moore, Branch researchers, Harry Waters from the MSFC TU Office, Mr. Parker, and RTI participated in the meeting. After the discussion and laboratory review, the group agreed to collaborate on an informal basis during the design phase (brainstorming, exchange of ideas, etc.) and agreed that as the design becomes more concrete, requiring significant resources, a formal agreement will be drafted. Light Age is currently proceeding with development of the display and has noted interest indicated by several additional science and national museums.

Problem Title: Computer Disc Drive Mechanical Problems

Date of Preparation: September 30, 1991
Source of Problem: Major U.S. Hard Disc Drive Manufacturer
RTI Team Personnel: Stephen A. Lehrman

I. Technology Requirement:

Technology is required to solve three related mechanical problems with hard disc drives. These three problems are:

1. eliminate bearing excitation frequencies and reduce spindle motor runout,
2. develop a non-ferrofluidic seal to protect the read/write mechanism from contamination, and
3. provide repeatable vibration measurement of spindle motors.

II. Background:

Most magnetic storage devices employ a stack of rotating discs upon which read/write heads "fly" on an air bearing a few microinches above the disc. The assembly which holds the heads is commonly referred to as an actuator assembly. The actuator assembly is a comb-like structure which locates the heads between the discs.

In the early generations of rigid, Winchester-type hard disc drives, the motor and spindle were two separate parts usually connected by a belt. The discs were located on the spindle which was rotated by the action of the motor and connecting belt. In contemporary designs, the motor is contained within the spindle, resulting in a spindle motor. Both actuators and spindle motors use ball bearings. The spindle motor uses a typical ball bearing application in that rotation is continuous, unidirectional, and of constant speed. The actuator application is atypical in that the rotation is through a limited arc and varies in both direction and speed.

Due to the narrow gap between the flying heads and the rotating discs, high performance rigid disc drives must be extremely clean. Permissible particles can be no larger than a few microinches. Therefore, the sealed area of the disc drive must be isolated from external conditions. Also, the sealed area of the disc drive must be isolated from contamination sources contained within the drive, such as interior parts of solenoids, spindle motors, and actuators.

Magnetic exclusion seals (i.e. Ferrofluidic seals) have traditionally been used to isolate both the external conditions and the interior motor environment from the

sealed area of the disc drives. The magnetic exclusion seal is basically an annular magnet sandwiched between two magnetic steel washers. The seal surrounds the rotating (magnetic) motor shaft with a gap of a few microinches between the seal washers' ID and the shaft OD. In some cases, the shaft may be stationary and the seal rotating. The ferromagnetic fluid is held in place by the magnetic "circuit" and fills the gap between the stationary seal side and the rotating shaft.

In this manner, the environment on one side of the seal is isolated from that on the opposite side. An additional benefit of this type of ferrofluidic seal is that it is a moisture barrier. Other sealing schemes, such as labyrinth seals, do not provide a moisture barrier. Also, the ferrofluidic seals are electrically conductive thus providing a grounding path for static potential generated by the rotation of the discs in air. When these seals are positioned outboard of the motor bearings, magnets, and other "dirty" components within the motor, the seals effectively isolate the contamination within the spindle motor. This is especially important if the interior of the motor is exposed to the outside world as is commonly the case.

Spindle motors are tested before assembly into hard disc drives. Mechanical Signature Analysis is a technique used to test spindle motors. The procedure entails monitoring the vibration output of a fixtured spindle motor with an accelerometer or capacitance probe. A dynamic signal analyzer is used to perform an FFT, resulting in a delineation of the frequency and amplitude content of the input time domain signal. The purpose of the testing is to identify those spindle motors with excessive vibration that causes excessive movement of the heads and discs and results in audible noise.

III. Description of the Problem:

This Problem Statement describes three related mechanical problems with the hard disc drives. These three problems are (1) spindle motor runout attributed to the spindle ball bearings, (2) difficulty in handling and maintaining ferrofluidic magnetic exclusion seals, and (3) repeatability of measurements using Mechanical Signature Analysis and the establishment of metrics by which to judge acceptable spindle motors.

Spindle Motor Runout

As disc drives get smaller and more information is packed onto less disc area, the ball bearings in the spindle motor and actuator becomes the limiting factor in reliable data recovery. The random movement (non-repeatable runout) inherent in such bearings has both frequency and magnitude content which is undesirable. The rotational energy of the spindle motor provides the forcing function that produces undesirable head/disc displacements. In addition, the frequency content of this excitement often plays into the excitation of system level resonances resulting in poor acoustic noise performance. Audible noise is a primary concern in modern designs.

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Great effort has been expended to produce very smooth ball/raceway finishes at affordable prices. The specified maximum non-repeatable runout for most steel ball bearings (52100 or 440) is about 20 microinches with average values of 9-12 microinches. The environmental requirements are listed below.

shipping conditions	-40C to 70C 5% to 95% relative humidity
operating conditions	5C to 60C 8% to 80% relative humidity
spindle motor lifetime	5 years continuous operation 30,000 start/stop cycles
spindle motor shock	100g shipping 15g operating (10ms half sine)

Future generations of hard disc drive spindle motors will require non-repeatable runout of less than 2 microinches. In order to attain this design goal, the spindle motor ball bearings may need to use different materials such as ceramic balls. Also, a different type of bearing, such as a sleeve bearing, air bearing, or magnetic bearing, may be necessary.

Spindle motors operate between 4000 and 10000 RPM. Any fluids or lubricants must be contained, have minimal outgassing, and function for at least 5 years. The cost should be comparable to conventional ball bearings, typically less than \$3.00. This cost may be flexible if the required technology justifies a higher price. The bearing dimensions are approximately 13 x 5 x 3 mm (OD x ID x height) and smaller.

Ferrofluidic Magnetic Exclusion Seals

Magnetic exclusion seals depend on ferrofluidic material to maintain the seal integrity. This fluid may contaminate the sealed area of the drive by outgassing or evaporating into the clean area of the drive. The loss of fluid through evaporation will also decrease the life of the seal. Also, the fluid may be splashed or otherwise released from the magnetic circuit which holds it against the motor shaft. This free fluid is then available to contaminate the disc drive.

Magnetic exclusion seals are extremely susceptible to contamination, handling damage, pressure gradients, and other common shipping conditions. Furthermore, the radically smaller disc drive designs of the future will limit the use of these seals because of space constraints.

Magnetic exclusion seals are typically used outboard of the contaminated interior of the spindle motor. They are commonly used in pairs. In some of the newer spindle motor designs a labyrinth seal replaces one of the magnetic seals. One magnetic seal must remain to establish the electrical grounding path between the rotating and stationary motor. If the spindle interior is exposed to the outside world, then two magnetic seals are required, serving the dual purpose of both a moisture and contamination barrier.

An alternative to ferrofluidic magnetic seals is desired. The seals could be a solid material, such as teflon, provided debris caused by wear is minimized. The seal material must provide a moisture barrier and provide electrical grounding of static electricity. The seal material cannot appreciably increase the friction load on the spindle motor.

Seals are no more than 1mm in height. They withstand pressures of 3 to 7 inches of water without leaking either fluid or air. The electrical resistance is less than 15 megohms at 0.100 microamps of current.

Repeatability of Vibration Measurements

Ball bearings used in spindle drives have characteristic natural frequencies, predictable from planetary gears theory, which aggravate system resonances. These nuisance frequencies have been experimentally verified and reside mostly below 1 kHz. Many of the higher natural frequencies above 1 kHz are also of interest as they relate to system resonances and, subsequently, audible noise.

Vibration testing using Mechanical Signature Analysis is used to identify spindle motors with excessive vibration. The spindle motor is "soft sprung" as shown in Figure 10. In general, the natural frequencies remain constant from test to test. However, the peak amplitudes of the resonant frequencies seem to vary over time

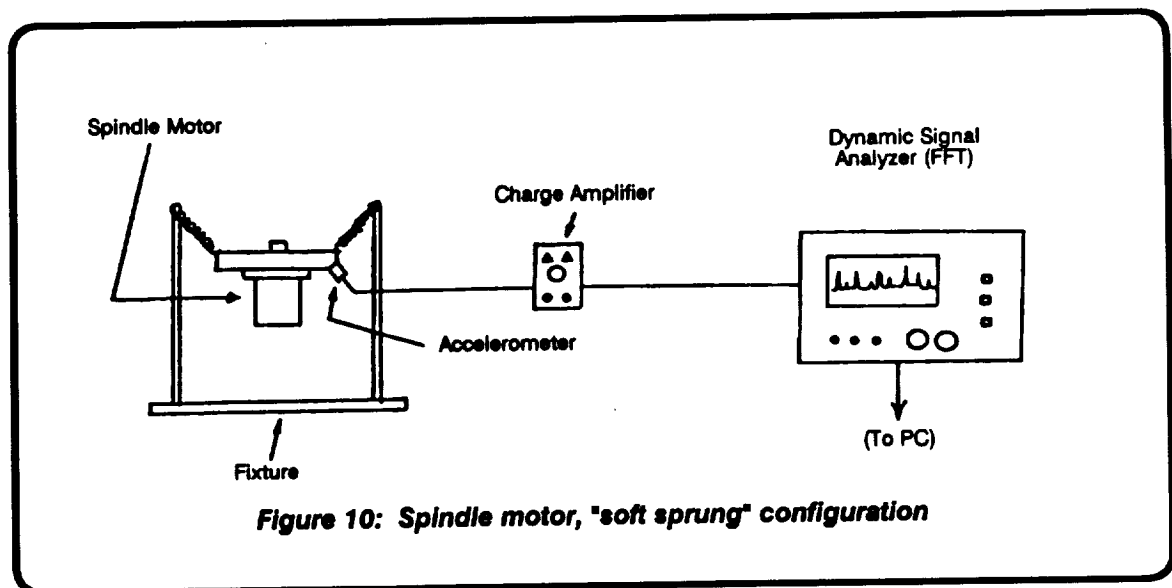


Figure 10: Spindle motor, "soft sprung" configuration

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in a periodic manner. This is evidenced by watching the frequency domain trace in a "free run" mode without averaging. Furthermore, when the spindle motor is removed from the fixture and then replaced in the fixture, the peak amplitudes of the resonant frequencies change.

Many approaches have been explored to make the Mechanical Signature Analysis vibration measurements more repeatable. Increasing the number of averages, modifying the fixturing to a rigid fixture, altering the FFT windowing, using time versus RMS averaging, changing the accelerometer location, adjusting the filtering, controlling fastener torque, and improving spindle speed control have all been tried without adequate success on improving measurement repeatability.

Because the vibration amplitudes are not repeatable, no universal criteria or metric can be established for the acceptance testing of the spindle motors. Presently, for each batch of spindle motors, a statistical approach is being used in which the spectral lines are summed for a range of frequencies (i.e. 50 to 70 hz for the 60 hz band), the measurement being an RMS value of the component spectral lines. This procedure is followed for all relevant frequency bands. After a large sample of spindle motors are tested, the mean and standard deviation are found for each frequency band. The distribution for each band is normalized. The specification then becomes set at some number of standard deviations above the mean amplitude value in each frequency band. When a spindle motor fails this criteria, the motor is built into a disc drive assembly and the drive function is evaluated. If no problems are found, then the specification is usually modified.

A method for acceptance testing of spindle motors needs to be established that does not depend on the particular "batch" of spindle motors being tested. Simultaneously, the problem of the vibration amplitudes changing during the testing needs to be addressed. This problem may be due to the fixturing or could be a nonlinear phenomena.

Problem Title: Convolver for Real-time Image and Signal Processing (CRISP)

Source of Problem: Mr. Daniel Perey, Langley Research Center
RTI Team Personnel: Dean Hering

Background

Dr. Joseph Heyman, Chief of the Nondestructive Evaluation (NDE) Branch at Langley Research Center referred the Team to Mr. Daniel Perey, who is managing the CRISP project at LaRC. The CRISP, based on a novel digital signal processing technique, enhances the quality of real-time signals from a variety of measurement systems. LaRC uses the CRISP to improve signal resolution for aircraft inspection, composites NDE, structural damage measurements, and high temperature measurements.

Mr. Perey's group was interested in finding a commercial partner to team with the group in developing a hardware version of the current software implemented technology. Additionally, Mr. Perey's group was interested in determining what industry requirements should be included in a commercial instrument, both from a manufacturing and user perspective.

Status

The Team contacted industry representatives from six different application areas, including a nondestructive evaluation industry association. Based on the information from LaRC and industry, the Team developed a four panel brochure describing the technology, benefits, market applications and customer base, system status, opportunity for commercialization, and invitation to a commercialization workshop in March 1992. The brochure includes a return postcard for user and manufacturer input. The CRISP Brochure will be used to inform potential corporate partners of the CRISP technology and to solicit industry/user input for incorporation into the developed product. Interested companies may attend the commercialization workshop, which RTI will assist LaRC in organizing and administering.

The first draft of the brochure was completed and sent to LaRC in August for their review. LaRC responded with minor changes in October. The camera ready brochure will be developed and sent to LaRC by November. The Team will then locate and contact industry representatives and send brochures to interested potential partners. The Team will review the response cards, compile the results for LaRC, and follow up with the companies sending ideas and comments. RTI will also assist LaRC in organizing, facilitating, and following up on a CRISP commer-

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cialization workshop in March 1992. The objectives of the workshop are to acquaint potential developers and users with the CRISP technology (including demonstrations and NASA application results), to present the market survey results and user input to potential developers, and to identify partners for the development and commercialization of CRISP.

Problem Title: Detection System to Identify Wetwood In Standing Living Trees and In Cut Logs and Boards

Source of Problem: Hardwood Research Council
RTI Team Personnel: Dean Hering
Date of Preparation: September 1991

I. Technology Requirement

Technologies are sought to separate bacterial infected lumber from non-infected lumber before drying and identifying infected living trees in the forest.

II. Background

A. Problem and Impact of Solution:

Bacterial wetwood is a condition present in the wood of living hardwood trees associated with the presence of bacteria, increased moisture content and a general increase in pH. Affected wood may be differentiated from healthy wood by its visibly darkened color, higher moisture content, decreased concentration of gaseous nitrogen and oxygen, elevated pH, decreased electrical resistance, abnormally high gas pressure and increased mobile cation content. In oak, the widespread occurrence of bacterially infected wetwood, commonly occurring in the inner cylinder or heartwood of the tree, was brought to the attention of the Hardwood Research Council in 1983 as a major limiting factor in the future utilization of oak lumber. Since that time, concerns have also been raised about identification of living oak trees in the forest infected with bacterial wetwood. Problems associated with bacterial infected oak lumber occur mostly during the drying process, but other problems associated with machining, finishing, gluing and odors have also been noted. While Northern red oak (*Quercus rubra*) is most commonly associated with bacterial infection, white oak (*W. alba*) has been shown to be infected also, to a lesser degree.

Bacteria that infect and colonize the heartwood of living oak trees tend to be anaerobic in nature and do not decay wood. The obligately anaerobic bacterium *Clostridium* spp has been most often linked to bacterial wetwood in oak, however other aerobic and facultatively anaerobic bacteria have also been noted to be associated with wetwood. Wetwood appears sound since these bacteria are unable to degrade either cellulose or lignin and there is no significant loss of specific gravity. Enzymes produced by the bacteria are able to degrade hemicellulose and pectins present in the middle lamella of the cell wall. This type of degradation leads to abnormal checking and "honeycombing" of the wood (separation of cell walls) during drying causing substantial loss of quality (degrade). Other bacterial species

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present in oak wetwood are able to enzymatically degrade various polyphenols including tannins which are present as wood extractives. This type of degradation can often lead to wood finishing problems and unnatural darkening of the wood during drying, sawing or bending.

The bacterial populations which colonize wetwood typically impart to the wood a characteristic rancid or sour odor due to the presence of volatile fatty acid metabolic products. Propionic, butyric, caproic and acetic acids have been detected in wetwood of various tree species, as well as other unidentified compounds.

Kiln drying (heat) of oak lumber is difficult due to the inherent variability between and within species, and due to the presence of wetwood. Normal drying schedules (time periods under set conditions) are not suitable for wetwood since steep moisture gradients develop that cause excessive degrade due to the weakened condition of the middle lamella in the wood cell walls. Most degrade is in the forms of excessive and deep surface checking, honeycomb, collapse and ring separation. In addition, shrinkage of the wood is increased. Common losses during kiln drying oak lumber are 10-25% of the dry lumber volume due to honeycomb and ring separation alone.

Bacterial infection of living oak trees is now believed to be widespread not only in red oak species, but in the white oak group as well. Environmental factors associated with the occurrence of wetwood in living oak trees are changes in land use practices; e.g. flooding, drainage of clay soils; overmaturity; root injuries; overtopping of crown by forest canopy (stress); growth on bottomland or clay soils; defoliation by insects, e.g. gypsy moth; and increased levels of air pollutants. Oaks growing on upland sites in well-drained soils are less prone to develop wetwood. It is difficult to identify living trees with wetwood unless some external indicators such as fluxing of bacterial metabolic products occurs on the bark associated with wounds (flux is forced out of the tree by gas pressures produced internally by associated bacterial populations). At present, the only way to identify bacterial wetwood in the trunk of standing, living trees is by felling or boring a hole into the tree.

B. State of the Art

Presently, there are no methods of detecting the presence of wetwood in living, standing trees except by felling the tree, boring a hole into the tree, or by noting the presence of "bleeding" or "flux" on the outer bark. These methods are not adequate to determine the extent or volume of wood tissue affected with wetwood within the tree, however.

The presence of wetwood in cut logs or boards can be noted by odors from fatty acids produced by the bacterial populations associated with wetwood or visibly by the watersoaked appearance of the wood. Human olfactory techniques are not satisfactory because the nose rapidly suffers "overload".

Aside from physical examination of the wood to detect the presence of wetwood, recent studies have addressed the use of chemical indicator compounds and detection of specific gaseous compounds associated with wetwood. Neither method has been shown to be successful.

III. Technology Constraints and Specifications

Technologies are sought which can provide an acceptable wetwood detection system or method for use on cut logs or boards. The solution must be able to determine the presence of wetwood in the wood rapidly, that is in the time it takes to sort the logs in the yard or deck prior to sawing or during the board sorting process on the mill green chain. The purpose of wetwood detection is primarily to segregate that wood affected from non-affected wood prior to kiln or air drying. The technology must also be simple to apply and analyze by the average millworker, and should be 80-90% effective in successful detection of wetwood. Suitable technologies could include artificial olfactory systems for detecting the presence of volatile fatty acid metabolic products, and systems to detect visibly darkened color, higher moisture content, decreased concentration of gaseous nitrogen and oxygen, elevated pH, decreased electrical resistance, elevated gas pressure or increased mobile cation content in the wood.

For detection of wetwood in standing, living trees, the technology solution must be portable in the field and able to be operated in all types of terrain and atmospheric conditions, e.g. self-contained including power source. Suitable technologies could include those that detect the fluxing of bacterial metabolic products or the large internal voids (honeycombing) not visible on the surface. Non-destructive evaluation would be a benefit. Time constraints for testing individual trees would not be a critical factor.

Problem Title: Mine Detection

RTI Team Personnel: John G. Cleland
Date of Preparation: August 5, 1991
Problem Originator: 40 West Project Management

Technology Requirement:

The government of Kuwait requires technology, equipment and expert personnel to perform underwater imaging of 1400 square miles of ocean bottom in shallow water to search for beach mines. Imaging and mapping determination are also needed to locate mines and unexploded ordinance on land (under desert sand).

Background:

A technology transfer opportunity for detection of subsurface and underwater land mines in the Kuwaiti coastal region is being investigated by the Applications Team. A company (40 West Project Management, Inc., Fullerton, California) is pursuing contacts with the Kuwaiti government in an attempt to access cost sharing funds for an applications project. No funding has changed hands as yet.

There appears to be no clear automatic or electronic method of clearing the mines in question.

Technical Requirements:

The mines are anti-personnel, anti-tank, and anti-ship types. Underwater mines along the gulf coast are typically in less than 20 meters of water. There are no known maps of mines seeded by the Iraqi military on beaches and in shallow water areas. Beach mines are of first priority, out to a water depth of 5 meters. Inland mines under shifting sands are second priority. It is not believed that the mines are of highly sophisticated types and that they should contain metal components, or even outer metal shells. Further definition of the characteristics of the mines along the Kuwaiti coast are being pursued.

New techniques have been and are being recently developed to find and destroy mines. Designers at the U.S. Army Belvoir Research, Development and Engineering Center, Fort Belvoir, VA are developing various types of electronic and mechanical systems. These include the Mine-field Reconnaissance and Detector System (Mirador) and an airborne reconnaissance system. Forward-looking infrared sensors and ground-penetrating radar are being applied to detect metallic and non-metallic mines. The sensors measure the difference in permittivity between target and soil. One neutralization method is called Vemasid, for Vehicle Magnetic

Signature Duplicator. It emits an electromagnetic signal that explodes magnetically fused mines before a vehicle such as a tank or truck reaches them. These methods do not appear to be efficient or even applicable for underwater mines.

Other types of underground detection have been applied in such areas as subsurface pipeline locations. References 1 through 9 provide a few examples of detection techniques that should be examined in the context of applying the best NASA technology.

NASA Technology:

Synthetic aperture radar (NASA Stennis Space Center, SSC) and Light Detection and Reflection radar-LIDAR (Mr. Frank Hoag, NASA Goddard Space Flight Center, GSFC) have technology transfer possibilities. LIDAR has demonstrated small object and plumes detection at water depths of 10 meters and appears to be an excellent option for mine detection. More information can be found in an article in Applied Optics, October 1988. LIDAR frequency is being increased to 800 pulses per second which will significantly improve resolution. Turbidity presents some problems. For dry sand, L-Band aperture radar should be considered.

Participants:

- Michael E. Quaranta, 40 West Project Management, Inc.
- Frank Hoag, GSFC
- Tom Seaver, SSC

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Problem Title: Motion/Torque Sensor for Measuring In-Vivo Hip Implant Stability

Date of Preparation: September 30, 1991
Source of Problem: Hennepin County Medical Center
RTI Team Personnel: Daniel L. Winfield

I. Technology Requirement:

A straightforward, easy to use device is needed to measure torque versus motion in order to assess the stability of hip implants during surgery.

II. Background:

A. Problem and Impact of Solution

Over 150,000 total hip replacements are performed in the U.S. each year, most resulting in remarkable pain relief and functional motion. A total hip implant consists of polyethylene socket implanted into the pelvis, which articulates with a ball attached to a metal stem anchored in the medullary canal of the femur. There are two methods used to anchor this femoral component within the medullary canal. Historically, most implants were fixed using a polymethylmethacrylate cement which acts as a grout between the implant and the bone. Failure of this cement post-operatively led researchers to develop implants which could be inserted without the use of cement. These implants and the associated instrumentation are designed to achieve a precise fit between the implant stem and the specially prepared interior of the femur. The implant stem is then held either by press-fit or by bone ingrowth, in which bone grows into specially designed surface porosity. Bone ingrowth and long-term fixation is not universal however, as revealed in reported results which show femoral component revision in up to 3.5% of cases and thigh pain (indicative of micro-motion) in 5-30% of cases. Bone ingrowth relies to a large extent on the mechanical stability of the implant. An implant which is stable under activities of daily living will promote bone ingrowth to occur.

Currently, however, there is no controlled method for surgeons to assess the mechanical stability of a newly inserted implant at the time of surgery. Judgement is left to the "feel" of the surgeon, which, while reliable, is not 100% accurate nor does it provide a controlled manner in which to study the effect of mechanical stability on long term implant performance. Stability is most crucial in a torsional mode as the greatest stress is applied to the implant-bone interface when the patient is in a position of rising from a chair or climbing stairs. In this position, forces applied

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onto the offset head or ball portion result in significant torque applied to the implant stem. This problem statement seeks an innovative method to apply torque to a hip implant femoral component during surgery and measure the resulting micro-motion. This micro-motion may be of the order of less than 100 microns, and the resulting torque vs. motion graph will help the surgeon to assess implant mechanical stability. In addition to use at the time of implant insertion, the device could be used when a previously implanted hip is being reoperated upon, for example to revise an acetabular component.

Such a torque/motion sensor will allow surgeons to conduct controlled studies to determine the range of implant micro-motion which can be tolerated and still achieve long term implant fixation through bone ingrowth. Once these ranges are established, if an implant demonstrates less stability, it could be removed and a larger implant or perhaps a different design implant could be inserted. In this way, the frequency of thigh pain and frequency of revision will be reduced from the current levels.

B. State of the Art

This problem statement deals with the fixation of the femoral component within the medullary canal of the femur or thigh bone. In non-cemented implants, various instrumentation is used to carefully prepare the femur for receiving the implant stem. A wide variety of implant designs are available and are selected on the basis of patient characteristics and surgeon experience. Figure 11 shows the typical position of patient during surgery. Once a design and tentative size are chosen, a

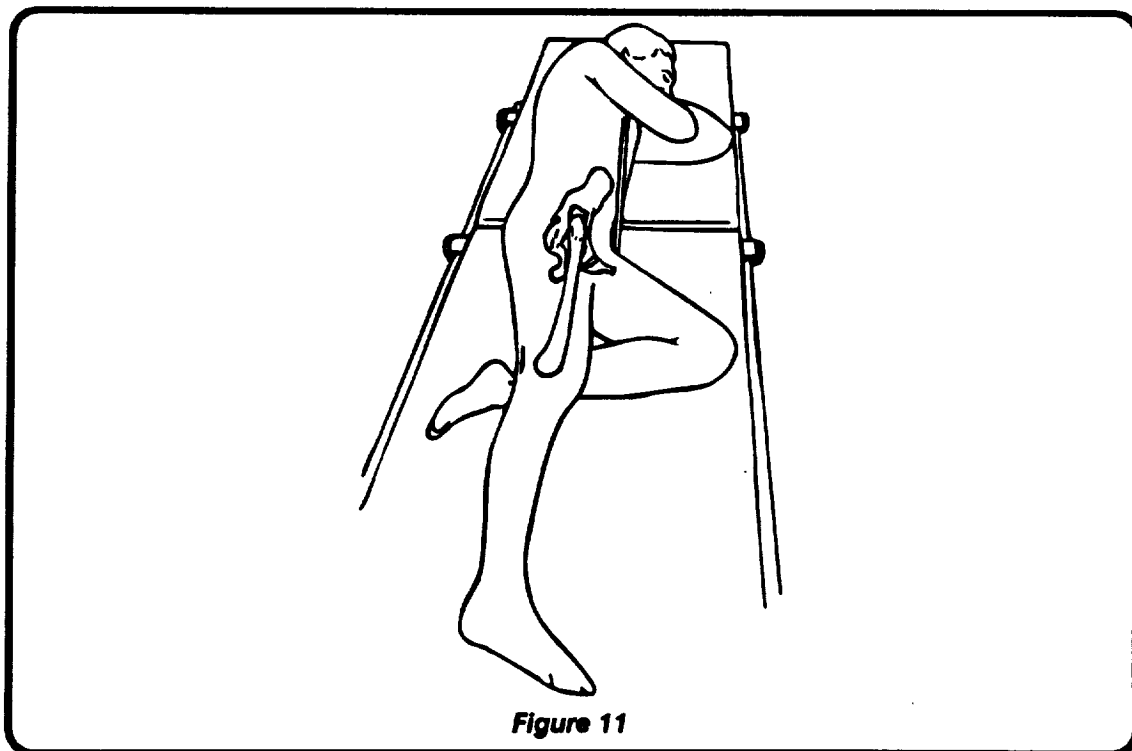
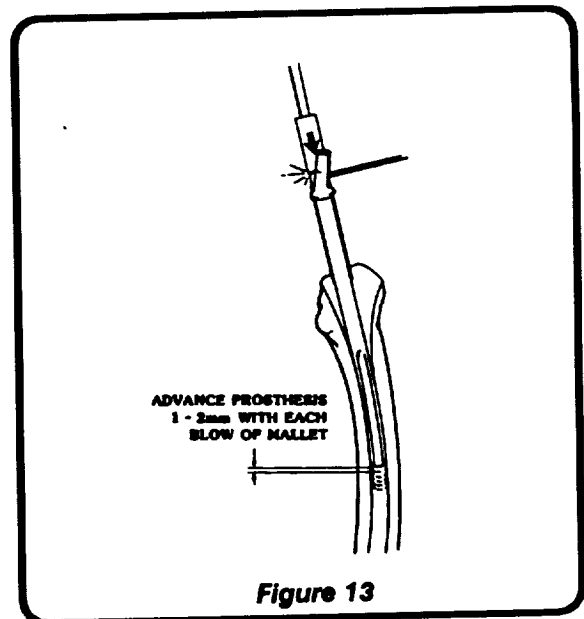
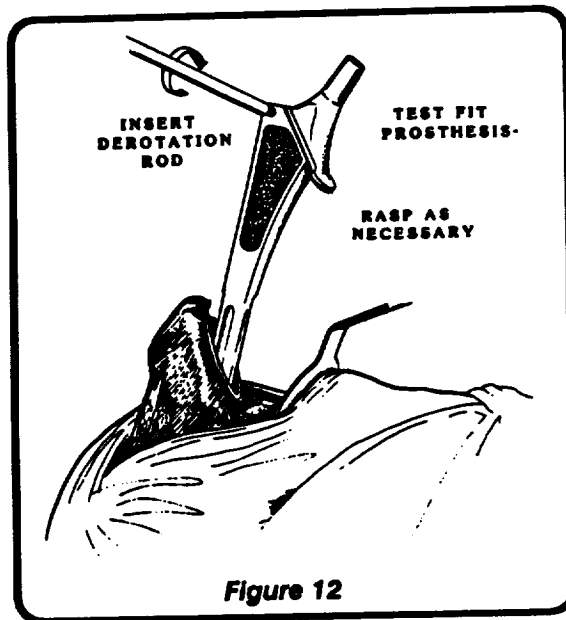


Figure 11

series of broaches and rasps are used to remove bone from the medullary canal in order to approximate its shape to that of the stem of the implant (Figure 12). Upon inserting the implant (Figure 13), a press fit is obtained. Adequacy of this press fit is judged by the surgeon manually applying force or torque and observing for any noticeable micro-motion between the implant and the bone. Acceptance of adequate fit is thus obviously variable among surgeons and probably variable between procedures by the same surgeon. Finally, a highly polished, spherical head is seated onto the trunnion of the implant.



As noted above, adequacy of mechanical stability is important to achieve bone ingrowth and long term fixation. Torsional forces are of particular concern, and in positions such as rising from a chair or climbing stairs, torque can reach 10 to 20 N-m. Exactly how much micro-motion can be tolerated and still achieve bone ingrowth is not known, but estimates range from 100 to 300 microns.

Once implanted, the only means to assess implant stability rely largely on radiographic signs. Careful x-ray technique can reveal locations of direct bony apposition to the implant, indicating potential for bone ingrowth to have occurred. On the other hand a reactive line appearing on x-ray is a major sign of failure to achieve ingrowth, but not necessarily stability. Other radiographic signs include remodeling of various portions of the bone in response to the altered force transmission through the implant to the femur. All of these signs are indicative, but confirmation of loosening requires a revision of surgery. During revision, the mechanical stability is reassessed. again manually.

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Some surgeons elect to leave in place an implant that is mechanically stable, while others choose to revise any implant with radiographic evidence and pain, whether stable at surgery or not. Again, a device to provide a controlled quantitative measure of implant stability should be helpful in revision surgery as well.

Only one similar device now exists in the market. This device is basically a modified torque wrench. However, it is adapted for use only with one implant design as it attached to the implant by insertion of a rod through a hole in the proximal portion of the implant. Thus it is not applicable with other implant designs, nor, more importantly, does it provide any means to measure micro-motion.

Several studies have been completed to measure implant stability in an in-vitro situation, i.e. in a laboratory testing apparatus. One such study is described in the attached article by Gustile, et al. An implant is inserted into a cadaver femur or synthetic bone femur in an identical manner as during the real surgery. The implanted femur is then placed into a torsional mechanical testing machine. Torsional motion is monitored by way of an RVDT, rotational variable differential transformer. Positioning for the RVDT is made via a rod through a special hole in the proximal portion of the implant and via pins or screws placed into the femur. Such a method could perhaps be adapted for intrasurgical use.

III. Technology Constraints and Specifications:

The conceptual device should be able to apply a known torque or force to a portion of the implant. This force might be applied to the head or ball or the implant, provided a method is incorporated to prevent scratching or otherwise damaging the head. The key element of the required device is the ability to measure relative movement between the implant and bone. Such measurement should employ a means to translate this movement to an estimate of movement at the bone-implant interface. Provided it is consistent with the surgical technique, it may be allowable to place one or more pins into the proximal femur as a reference. Alternatively, it may be possible to use a non-contacting method to measure movement of both the implant and the bone and to use a differential approach to determine relative movement between the two. Other creative means to monitor micro-motion are sought as well.

The conceptual device must be fairly simple and convenient to use during surgery. It should include a minimum of peripheral equipment, preferably none. Figure 4 was included to show the typical surgical access, and this must be taken into account in any proposed approaches to this measurement. All portions of the unit which must contact the patient or the implant or otherwise enter the surgical field must be capable of being sterilized (preferably by steam sterilization, alternatively by ethylene oxide gas) without affecting device performance.

Problem Title: PMR-II-50 and VCAP Polyimide Market Assessment**Source of Problem:** Lewis Research Center**RTI Team Personnel:** Stephen Lehrman**Background:**

At the request of the Lewis Research Center Technology Utilization Office, the Applications Team investigated the commercial applications for PMR-II and VCAP polyimide resins and their laminates. Dr. Charles Chiklis, a consultant to the Research Triangle Institute's Department of Polymer Science, prepared a report that recommends that the polyimides have niche application as high temperature materials for printed circuit boards, filters for flue gases, and adhesives. All of these applications take advantage of the superior thermo-oxidative stability of these materials at elevated temperatures.

Status:

Dr. Chiklis and Stephen Lehrman met with Dr. Michael Meador, Polymer Branch Chief, at Lewis Research Center. Dr. Chiklis presented the findings of the investigation and discussed the applications. In the adhesives area, it was decided that the Applications Team would contact American Cyanamid to discuss the status of a proposed Space Act Agreement that was never signed. The Applications Team also agreed to develop a better understanding of the technical requirements for the high temperature filters and printed circuit boards.

Stephen Lehrman contacted Mr. Steve Peake, Manager of Adhesives Research at American Cyanamid. Mr. Peake was unaware of the proposed Space Act Agreement but did agree to review it. After his review and further conversation, Mr. Peake stated that he was interested in American Cyanamid executing the Agreement. He said that he was sending the Agreement to American Cyanamid's attorneys for their review. The Applications Team expects that the Agreement will be signed in the second quarter of Fiscal Year 1992.

Dr. Chiklis contacted the U.S. office of Lenzing, A.B. in order to obtain technical information on their flue filter fabric. He also contacted the Microelectronic Center of North Carolina and DuPont Electronics to develop an industry requirements statement for advanced circuit board material so that we can compare the properties of the NASA polyimide materials with the electronic industry needs in this area. The Applications Team expects that this information will be used to develop a problem statement.

Problem Title: Portable, Powered Seat Lift

Source of Problem: Dr. David Gaw, Nashville, TN

RTI Team Personnel: Doris Rouse, Aubrey Smith

Background:

The objective of this project is to design, develop, evaluate and produce a lightweight, portable, powered seat lift to assist people with impaired mobility in rising from a seated to a standing position. Many older people with degenerative conditions of their back, hips, or knees are in need of such a device. There are an estimated 5-8 million people in the U. S. with mobility impairments, and many of these could be assisted by a functional, portable seat lift. Also, nursing homes and intermediate care facilities could make good use of such a device. Dr. David Gaw had conducted a thorough search for a satisfactory seat lift. Two such devices on the market have severe drawbacks: (1) the Assisto-Seat is a spring loaded seat that provides a spring force to the buttocks but with no control over speed. Also, it is very difficult to close for carrying after you have risen. (2) A Pneumatic Seat Lift is also available but is too heavy and difficult to transport. Unable to locate a satisfactory seat lift, Dr. Gaw contacted NASA and the RTI Applications Team for assistance. The RTI team discussed the need with the National Institute on Aging, the Department of Veterans Affairs, and the National Institute on Disability and Rehabilitation Research and confirmed that this is a major problem for the elderly. A reasonably priced solution would benefit a large population of older persons as well as others with physical impairments. The seat lift must:

- weigh less than 10 pounds,
- be less than 2.5 inches thick when closed,
- exert sufficient force to raise an average adult to a near standing position,
- provide stability during a rate of lift of 3 to 5 seconds,
- provide long term reliability,
- be operated by the user alone, and
- be clean, safe, and as quiet as possible.

NASA Technology

The NASA Marshall Space Flight Center has developed ultra-efficient, lightweight mechanisms and very compact DC power supplies for many space applications,

e.g. deployable space mechanisms. MSFC has instituted a project to design a mechanism and power supply to meet the stated requirements.

Participants

- Bruce Weddendorf, MSFC
- Dr. David Gaw, Nashville, TN
- Alec Pearce and Associates, Durant, OK

Status

Engineers at MSFC modeled the kinematics of a person rising from a chair and developed a design for an electromechanical seat lift. The patent application has been filed on this design. The design was reduced to engineering drawings and a non-load bearing, but functional, mock-up is being fabricated at MSFC. Engineering drawings have been supplied to Dr. Gaw who has obtained quotes for producing a fully functional prototype. Alec Pearce and Associates have undertaken a re-design in an attempt to reduce projected manufacturing costs.

Actions

RTI will monitor project progress and provide assistance for a working prototype to be built and evaluated.

Problem Title: Rotating Cell Culture Vessels

Source of Problem: Glenn Spaulding, JSC

RTI Team Personnel: Daniel L. Winfield

Problem

Many biomedical studies and clinical applications require the culturing of specific cell types. Current cell culture technology has a number of limitations. While certain cell types can be grown to proliferation, other types are very difficult to grow and/or very slow to proliferate. In addition, when cells proliferate in a Petri dish, they flatten out in a laminar fashion and exhibit few of the three dimensional intercellular structural features seen in the human tissue counterpart. For many applications, it can be expected that a cell culture method that produced more culture which closely resemble tissue structures would be highly valuable. This will allow improved means to test therapeutic drug (e.g. chemotherapy for certain tumor types) and may eliminate the need for animal models in many areas.

NASA Technology

As a part of NASA's space bioprocessing research, JSC has developed horizontal cell culture vessels which rotate as a means to simulate the lack of sedimentation that occurs in microgravity. On Earth JSC researchers have used these rotating cell cultures to grow a variety of heretofore difficult to culture cell types.

In addition, three dimensional tissue masses resembling pol???? have been cultured. This new method offers tremendous potential in numerous biomedical areas.

Status

Patents have been obtained by JSC and licensed to a new start-up company called Synthecon. In response to an RTI-circulated request, JSC submitted technical information to the American Cancer Society. ACS has identified several interested collaborators to pursue one or more cancer applications of the technology. JSC has allocated funding for FY92 (\$60K).

Action

Work with ACS to select one or more collaborators to work with JSC. Develop complete project plan for cancer applications. Work with investigators to secure co-funding from ACS.

Problem Title: Thermal Insulation Coatings

RTI Team Personnel: John G. Cleland
Date of Preparation: August 20, 1991
Source of Problem: Mr. Richard Woodruff, Phoenix Engineering, Plantation, FL
 Mr. Robert Schendel, Texas Components, Houston, TX

Technology Requirement:

Coatings (0.003 to 0.300 inch thickness) are sought which possess low thermal conductivity and high emissivity. Heat resistant coatings are needed for thin panels and other structures where volume is restricted. Thermal protection over a wide range of temperatures is being considered.

Background:

Commercial organizations have contacted the RTI Applications Team seeking better insulating coatings. Applications include roofing coatings, coatings for lightweight containers, for refrigerator enclosures, for ovens, and for vehicles. In one application, it is desired to bring a 40 pin electronics microchip up to temperature with hot nitrogen gas. The enclosure for the inert atmosphere is restricted in volume and the process would benefit from the uniformity of and stability of temperature promoted by a good interior insulation coating. Another application is for coating large surfaces of relatively flat galvanized steel. This coating would go onto commercial air conditioning equipment and be applied in-situ. Low cost and practicality in manufacture, availability, and application are important for all the cases that are being considered.

The primary emphasis is on obtaining coatings with low thermal conductivity. For comparison, some common insulating materials and their conductivities near 300 °F include:

<u>Material</u>	<u>Conductivity (Btu/ft-hr-°F)</u>
Diatomaceous earth	0.04
Asbestos	0.11
Kaolin brick	0.15
Rubber	0.09
Zirconia	0.80
Air	0.02
Glass	0.50

Other forms of thermal barriers, such as high-temperature polymer or ceramic matrix foams, can be considered in some cases for thicknesses up to 1/4 inch. Such

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foam materials as urethane castings have already been investigated and rejected. A matrix with hollow glass spheres is considered to be a possible solution, if any NASA work has been done on such a material. Coatings may also play an important role in chemical reaction protection as well as thermal insulation.

Some success has been achieved using ceramic fibers (e.g., silica alumina) and ceramic microspheres in a sprayable binder matrix. The problem here is that the binder becomes the main conductor. Coatings with R values down to 1.5 have been obtained for 60 mil thick layers.

Technical Requirements:

Requests have been made for coatings to cover substrates to would produce a thermal resistance of $R=4$ to $R=6$ (thickness/area - thermal conductivity, $\text{hr}^\circ\text{F/Btu}$), for a thickness not to exceed 60 mils (20-30 mil preferred). This is an equivalent conductivity of 0.01 to 0.02. For comparison, acrylic and urethane bases one inch thick have an R value of about 8. Strength and toughness resistance to flexure and abrasion have not been indicated to be of significant importance for most of the applications described. It is usually preferred that coatings can be sprayed onto a surface, although a cost-effective sputtering or chemical or physical deposition technique would be acceptable.

For one surface coating requirement, temperatures will never exceed 200°C . For an oven application, a k value of 0.01 is sought for temperatures approaching 1000°C . This is an extremely challenging requirement.

Reducing binder content for matrix material coatings is another criterion.

NASA Technology:

Zirconia and yttrium oxide coatings are materials which NASA has developed, especially at NASA Lewis Research Center for rocket nozzles. These coatings are best for very high temperatures. Environmental stability and longevity of the materials are important to NASA and also to industry interests in thermal coatings.

The NASA Ames Research Center is currently working with intumescent paints, i.e. coatings which swell when heated. Performance values will be obtained later for these materials.

The NASA Goddard Space Flight Center has developed an alkali-metal silicate binder [1,2] (and a method of manufacture) that may offer somewhat lower thermal conductivity than binders previously investigated.

Some high-performance coatings have been developed for the NASA Space Shuttle Thermal Protection System [3]. However, most of these are chosen for their

high-temperature resistance and their emittance characteristics in high-radiation environments rather than low thermal conductivity. Some of the binders developed for TPS coatings might be of interest. The NASA Johnson Space Center has also developed a 0.16 inch thick coated-felt thermal insulation for the TPS, but conductivity values have not yet been obtained for purposes of this Problem Statement. The felt can be applied to a surface with a room temperature vulcanizing adhesive [3].

A low-density, sprayable thermal insulation ("MSA-2") developed at the NASA Marshall Space Flight Center has been applied using the robotic spray system shown in the Figure. The foam is applied at thickness of 1/2 inch or less and has a thermal conductivity as low as 0.035 Btu/hr-ft-°F [4].

Participants:

The principal commercial interest at this point is Mr Woodruff of Phoenix Engineering. However, the coating problem is practically universal. NASA participants from all Centers are sought who have experience and knowledge in thermal barriers and coatings.

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Problem Title: Treatment of Wastewater Containing Nonionic Surfactants

Problem Originator: American Society of Mechanical Engineers and
Independent Lubricant Manufacturers Association
Date of Preparation: July 16, 1991
RTI Team Personnel: Stephen A. Lehrman

I. Technology Requirement:

Membrane (ultrafiltration, reverse osmosis), ion exchange, activated carbon, biological treatment, and oxidation (supercritical, wet) processes to better remove nonionic surfactants from wastewater.

II. Background:

The metalworking industry uses oil-water emulsions and cleaners in applications such as machining, grinding, parts washing, floor scrubbing, etc. Higher quality emulsions (for better stability and longer life) are now commonly used to reduce the volume of wastewater. Nonionic surfactants used in these formulations are difficult to treat and remove from the wastewater.

Typical oil-water emulsions, such as soluble oil, semisynthetic, and synthetic metalworking fluids, use anionic surfactants as the basic chemistry for most formulations. Chemical treatment methods such as neutralization and coagulation are effective in treating wastewater containing anionic surfactants prior to sewer discharge.

Nonionic surfactants can be used in small proportions to stabilize emulsions. Ethoxylated alcohols, ethoxylated alkyl phenols, aliphatic polyethers, and glycol ethers are commonly used as nonionic surfactants. These materials are difficult to chemically treat in wastewater due to their extreme water solubility.

III. Technical Requirements:

Opportunities exist for innovative formulations that make waste treatment easier and more effective. Current technologies permit fluid recycling to help extend fluid life. Ultimately, final waste treatment is required. In addition, cost-effective solutions for total water reuse are desired, where cost-effective waste treatment processes permit water recycling or reuse.

Membrane techniques such as reverse osmosis, oxidation techniques such as supercritical water oxidation, and ozone induced biodegradability are promising methods for removal of nonionic surfactants from wastewater.

IV. NASA Technology:

NASA has performed research and development for long duration manned space flight on the removal of soaps and detergents from wastewater. Ames Research Center has developed a batch mode, supercritical water oxidation reactor for processing wastewater containing anionic surfactants. Ames plans to study removal of nonionic surfactants from wastewater in the future.

Johnson Space Center has evaluated a microgravity whole body shower and wastewater recovery system (WWRS) in three separate closed loop tests. The WWRS processes evaluated during the test series were phase change distillation and reverse osmosis dynamic membrane systems. A preprototype Thermoelectric Integrated Hollow Fiber Membrane Evaporation Subsystem phase change process was used for the initial test with chemical pretreatment of the shower wastewater.

Allied-Signal Aerospace Company has used a reverse osmosis membrane-based recovery system for purifying Space Station shower and laundry washwater. A systematic study was conducted of the thermal stability of a proprietary membrane at 74 C and 200 psi operating pressure. Experiments were performed on membrane coupons, and performance of the membrane when exposed to anionic, cationic, and nonionic surfactants.

V. Participants:

The American Society of Mechanical Engineers Center for Research & Technology Development and the Research and Development Committee of the Independent Lubricant Manufacturers Association are sponsoring this project.

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7.0 COORDINATION OF ONGOING PROJECTS

Application of Artificial Intelligence to Adult Literacy Training

RTI Team Personnel: John Cleland, Stephen Lehrman

Problem

Integrate Intelligent Computer Aided Training (ICAT), speech recognition, and speech generation into an artificial intelligence system that mimics the expert advice of a reading teacher.

Adult literacy is a major societal problem. More than 27 million Americans are functionally illiterate and another 45 million are marginally literate. The most effective reading diagnostic tests are performed on an individual basis. This level of concentration allows diagnosticians to discover causes of reading deficiencies unique to the pupil's handicap. The evaluation of these tests results in a prescription particular to that individual's needs or deficiencies. However, there are not enough reading instructors for individual training for everyone who needs it.

Advanced technology is being used to improve adult literacy. In July 1988, Pennsylvania State University hosted the Adult Literacy and Technology National Conference. Both IBM and Apple Computers have developed computer-assisted instruction programs for adult literacy education. The IBM program, PALS, uses a touch screen monitor, interactive laser video disc, and graphical representation to instruct the pupil. Apple Computers has an Adult Education and Literacy Department.

NASA Technology

NASA has an extensive research and development base in artificial intelligence, intelligent computer-aided training, speech recognition, and speech production. Johnson Space Center is already working on an Intelligent Physics Tutor based on the ICAT concept.

Participants

- James Villareal, JSC
- Mr. Kevin Jackson, National Institute of Corrections

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Status

JSC Software Technology Branch (STB) hired Dr. David Yaden of the University of Houston for the summer to develop the Literacy Tutor curriculum. The STB is developing the student diagnostic model. Much of the Physics Tutor models are being used to create the Literacy Tutor.

The Applications Team and Kevin Jackson (NTC) have discussed the project with Dr. Gail Schwartz of the Office of Correctional Education, Department of Education. Mr. Jackson plans to meet with Dr. Schwartz next quarter.

The Applications Team has also discussed the project with Linda Roberts of the Office of Technology Assessment. OTA is preparing a report on *Emerging Communications and Information Technologies: Implication for Illiteracy and Learning*. The JSC TU office has sent information to OTA on the Literacy Tutor Project.

Action

The National Literacy Act of 1991 (P.L. 102-73) authorized a new program in functional literacy for state and local prisoners. The Act authorizes the appropriation of funds to be used by the chief correctional officer of each State correctional system to establish a demonstration or system-wide functional literacy program. The program is administered by the U.S. Attorney General.

Dr. Gail Schwartz heads the Department of Education's Office of Correctional Education. The Application Team continues to correspond with Dr. Schwartz regarding the status of the project.

The Applications Team plans to continue working with the Department of Education, Department of Justice, and State of Texas Correctional System on planning and funding a demonstration program in Texas.

Augmented Telerobotic Technology

RTI Team Personnel: John G. Cleland

Problem

Application of NASA technology to develop shared control of telerobotic devices is needed, with particular attention to telerobotics utilization in both undersea and Space Station assembly and/or operations.

The basic premise of teleoperation is that a human operator is in full control at all times. A robot, on the other hand, can operate without continuous human intervention. A telerobotics device can be viewed as a hybrid between these two. Selective autonomous telerobotic operation can reduce operator fatigue by occasionally eliminating the need for an operator's physical effort and mental attention to details. During a selected autonomous operation, the human operator assumes a supervisory role that is far less demanding, particularly during the execution of highly repetitive tasks. Other important areas where autonomous control can be highly beneficial include collision avoidance (especially in compact and complex work areas) and contour following where standard contours can be programmed for response through the robotic controller.

Development of autonomy augmentation of telerobotics could be applied in such fields as undersea engineering, mining, medicine, and nuclear materials handling.

Kraft Telerobotics, Inc., and others in the telerobotics area are highly advanced in the teleoperated modes of operation. However, telerobots, with the autonomous operating capabilities of these systems, are less advanced. The NASA Flight Telerobotic Servicer program, and other telerobotics efforts being sponsored by the Office of Aeronautics and Space Technology, include research and development of sensors and feedback control/response to add more autonomous operation for space telerobotics. This is a part of NASA's evolutionary design to move from strict teleoperation to more and more autonomous systems. Langley Research Center, in particular, has been working in conjunction with the Oak Ridge National Laboratories to develop such devices as acoustical sensors for proximity sensing and collision avoidance control. Research is underway to apply a laser scanning diode for contour following. A commercial user's panel on telerobotics (organized by the RTI Team) indicated that NASA technology in sensing would be the highest priority on a list of technologies to be accessed by industry and applied to telerobotics.

Technology Constraints and Specifications

Projects to enhance operation through minimized teleoperator attention would employ sensors to share control with the operator. Initially, simple binary sensors may be employed to augment the system. New sensor technology and computer software development would expand existing technology of such companies as Kraft to provide the basis upon which selective autonomous operation will improve. A set of priorities in performing this augmentation could include:

- Survey literature on sensor needs and discuss needs with NASA technical experts
- Design telerobotic mount
- Procure and install mount and hydraulic system
- Install a dual arm telerobotic system
- Refine augmented telerobotic research tasks
- Complete definition of major technology transfer objectives with commercial concern
- Conduct automated telerobotics research program with routine consultation with NASA
- Report results of technology transfer effort and incorporate results into product line.

Status

The RTI Technology Applications Team discussed the project with the University of Kansas and with the Automation Technologies Branch at the NASA Langley Research Center (Dr. Al Meintel). The University of Kansas completed the details with the State of Kansas (cofunding) and with Kraft Telerobotics. Funding has been forwarded to the University of Kansas through LaRC.

Action

RTI evaluated and assisted with the final contents of project plans from the University of Kansas and Kraft Telerobotics, including costs. RTI re-contacted Dr. Barr to finalize plans for initiating the project. RTI participated in an LaRC projects review last quarter. It was indicated that two transfers 1) an improved stereo-vision system and 2) a PC monitor-based robot teach pendant have occurred since initiating the project. RTI re-contacted Dr. Barr this quarter and is planning a visit to the University of Kansas.

Collision Avoidance Algorithms for Radiation Treatment Planning

RTI Team Personnel: Daniel L. Winfield

Problem

Collision avoidance algorithms and simulation methods are needed to prevent inadvertent collisions between radiation treatment equipment or beams and the patient or treatment table.

The National Cancer Institute Radiation Research Program has funded a Collaborative Working Group of three leading medical universities to develop sophisticated computer-based software tools for radiation treatment planning. The objective is to make three dimensional radiation treatment planning a routine activity. These new tools should aid the clinicians by improving localization of radiation to tumors, lessening damage to normal structures and enabling more optimal selection of therapy.

This group's first year effort has been directed at looking for applicable technologies, and they have made an inquiry to NASA for certain software technologies. The first of these inquiries is for collision avoidance algorithms both for the planning simulation and potentially for real-time control.

NASA Technology

Two possible sources of NASA technology have been identified: (1) Charles Gott, Johnson Space Center, has proposed the adaptation of three dimensional simulations (used in orbiter operations development) to identify potential collisions during the treatment planning process, and (2) Dan Wegerif, Merritt Systems, Inc. (SBIR for KSC), has proposed use of a skin sensor system for proximity sensing to avoid collisions during real-time operation of the radiotherapy equipment.

Status

Both investigators have been put in touch with the problem originators, and we are currently evaluating these opportunities before determining whether to proceed with a project.

Action

Reach a decision on the viability of these concepts, and, if appropriate, assist the relevant Center in preparing a project plan.

Detection of Contraband

RTI Personnel: John Cleland, Jeff Antley

Problem

Contraband detection in correctional institutions focuses mainly on weapons and drugs. A system is needed that can detect contraband on and in people using rapid, non-intrusive methods. In addition, rooms, shops, fields, and packages need to be searched for contraband.

"Body packers" are people who swallow, or place within their rectums or vaginas, packets of drugs to avoid detection by prison or customs officials, see Figures 1 and 2. Before 1982, body packers detected by customs had a mortality rate greater than 50 percent. Although the practice is extremely dangerous, considerable amounts of drugs such as cocaine are transferred or hidden in prisons in this manner. Package materials range from toy balloons, to latex gloves, to condoms. These containers are usually folded over several times and tied tightly. Package size ranges from 1 to 12 grams, and as many as 200 have been found in one person. For cocaine, a lethal dose is from 1 to 3 grams, and death may occur from only one ruptured package. In addition, the large volume of indigestible material may lead to obstruction of normal body processes.

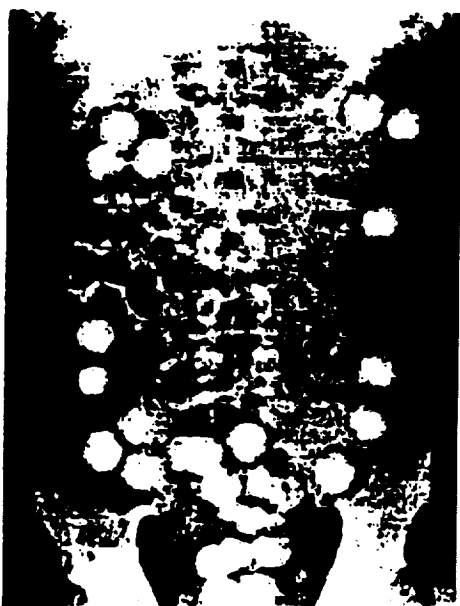


Fig 1: Abdominal roentgenogram shows cocaine packages.

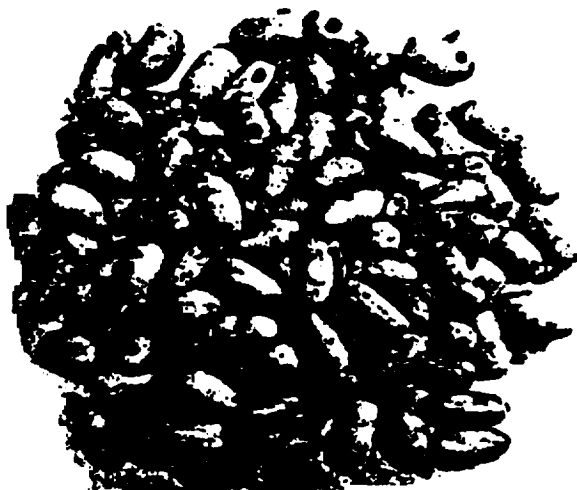


Fig 2: 103 packages of heroin wrapped in condoms.

In addition to drugs, knives or other small homemade weapons may be "keester stashed," in prison parlance. Hidden contraband in prisons is one of the most important problems identified by the National Institute of Corrections (NIC).

The problem identified is how to detect these materials on a routine basis in a large prison population and within legal restrictions. NIC seeks near real-time, continuous scans for contraband hidden within the gastrointestinal tract. Ideally, the system would be placed in a well-travelled hallway or a traffic bottleneck. Similar systems would also benefit Department of Customs officials and Drug Enforcement Agents in airports or seaports.

State of the Art

Presently, there are no methods which detect small packages hidden in body cavities except by immobilizing the person and taking a Roentgenogram or performing a rectoscopy. In cases where contraband has been detected, the subjects volunteered to be scanned or they became intoxicated because of broken or permeable packages. In both instances, the subjects were transported to a nearby hospital for examination.

Aside from physical examinations, methods by which hospitals detect hidden packets include radiography and computed tomography (3-D radiography). Packets that are not tightly wrapped, and therefore contain one or two air layers or "haloes," detect well on a common radiograph. Vacuum-packed drugs may not be observable. The density of the drug affects its detection by radiography: hashish displays +700 HU compared to +80 HU for fecal matter; cocaine (-219 HU) and heroin (-520 HU) are therefore virtually invisible to X-rays.

Magnetic resonance imaging, or MRI, is a new technology which creates images from within the human body. The process involves recording the frequency response of hydrogen atoms within an immobile body as a result of the atoms being placed in high magnetic fields. Currently, scanners consist of a transmitter and a collector magnet that surround a small platform on which the subject lies, and the maximum rate of data collection is on the order of 16 to 20 "slices," or images, per second.

Technology Constraints and Specifications:

An acceptable system must not be restricted by material types, must swiftly collect data and present results within less than 1 hour, must safely scan through common materials, and must be safe for continuous use and multiple exposures. Only positive threshold detection is necessary and not precise imaging. The system should have a threshold of positive identification of 2 to 3 grams and be able to

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detect both air-laden and vacuum-packed packages. It should scan mobile subjects and be non-intrusive and non-contacting.

While CAT scanning and related tomography approaches are rapid and definitive, they present a problem of repeated exposures to X-rays. Three-dimensional computed tomography often requires injection of a low-level radioactive tracer. There are indications that the U.S. Army will be purchasing a 1-second full-body CT scanner for field hospital operations, but this has not been confirmed.

MRI will be disrupted by any metallic material placed inside the scanner, so, since the electromagnets used for scanning create a field up to 1.5 tesla, the subject must be free from any magnetic material. The scanner must be shielded from external radio frequencies. As with CT, subjects typically must remain still while inside the scanner. Although the rate of data collection is high (16 to 20 slices per second), complete scanning of an entire body could take more than a few seconds.

For universal applicability, such a scanner should not cost more than \$500,000 per unit.

NASA Technology

Preliminary indications have been provided by Dr. Stan Manett at the Jet Propulsion Laboratory that nuclear magnetic resonance (NMR) could be employed satisfactorily in contraband detection, although methods for meeting the restrictions above have not been specified. JPL's first thoughts include:

- Employ permanent magnet at low field (600-2000 gauss or 0.06- 0.20 tesla)
- Employ body coils that slide in front and/or back of subject
- Lower resolution well below that required for medical applications
- Eliminate most FDA requirements, since medical diagnosis is not required
- Mass produce system for \$70 to 100K with development costs of \$3 to 4M.

Participants

- Mr. Kevin Jackson, National Institute of Corrections

Status

The RTI Applications Team has conducted literature surveys related to contraband, body-packing, MRI/NMR, and computed tomography. The Team has talked with Dr. Manett, Dr. Michael Vannier of Washington University, Dr. Pickett from Ad-

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vanced NMR Systems, and Dr. Larry Clark of University of South Florida, all experts in MRI and/or CT.

A meeting was held last quarter with NIC, NASA and the U.S. Customs Service to set mutual priorities and arrange a cooperative project. A series of teleconferences were held by the Team, NASA Code CU, the National Institute of Corrections, the Office for National Drug Control Policy, the US Customs Service, JPL, and Quantum Magnetics, Inc to discuss a coordinated funding and technical research approach to solving the contraband detection problems of interest to all the organizations. Progress continues but final decisions remain on imaging versus quantitation NMR identification.

Action

The Team will re-evaluate funding requirements and co-funding sources and report to NASA and NIC. The ONDCP will be re-contacted in the next quarter to determine disposition of research funds for FY92. A decision will be made in the next quarter to pursue this technology or to emphasize other corrections problems.

Development of an Intelligent Tutoring System for High School Physics

RTI Team Personnel: Stephen A. Lehrman

Problem

The federal government has cited the poor performance of American students in mathematics and science as a national crisis that must be addressed. In 1986-1987, the American Institute of Physics conducted a nationwide survey of secondary school teachers of physics. One of the Highlights of this survey was that in comparison to other countries, American students fare poorly in terms of both the proportion of students exposed to physics and the performance of those enrolled in the most advanced courses offered.

The integration of the computer into the K-12 instructional program began in the 1960's and has accelerated with the availability of inexpensive microcomputers and a growing amount of useful instructional software. The bulk of the computer-aided instruction today is limited to rather simple programs that are useful for drill- and -practice, automated "page-turning" and the administration of objective examinations. Only a small percentage of the educational software available today for K-12 use simulation, extensive branching to diagnose and remediate and/or artificial intelligence (AI) technology.

NASA Technology

The Artificial Intelligence Section at NASA JSC, in cooperation with the faculty at the University of Houston, has developed expertise in the application of AI technology to the training and/or tutoring task. They have developed a prototype intelligent tutoring system (ITS) for tutoring students in the production language CLIPS. This system has a general purpose user interface that should be adaptable to a variety of tutoring tasks.

NASA plans to use this expertise to develop an intelligent tutoring system for use in the first year of high school physics. The goal of this ITS would not be limited to the conveyance of facts and concepts but would concentrate on transferring problem solving skills to the student. Ultimately, this project would also provide a development structure suitable for building additional intelligent tutors for other academic subjects which require the application of problem solving skills.

Participants

- Dr. R. Bowen Loftin, University of Houston-Downtown

Status

The project is in the final year of a three year development. JSC has decided not to continue with Phase 2 of the Memorandum of Understanding with Knowledge Revolution, San Francisco, CA. Instead, JSC is negotiating a MOU with Holt, Rinehart & Winston (HR&W), Austin, TX to market the Physics Tutor Software in conjunction with HR&W's high school physics text. JSC is also discussing with North Carolina State University's Physics Academic Software group an agreement to market a slightly different version of the Physics Tutor to colleges.

Action

The Applications Team's involvement in the project is completed for the time being. The JSC TU Office is continuing negotiations with HR&W to commercialize the Physics Tutor Software. If the negotiations are successful, HR&W will fund future development. Otherwise, the Applications Team may be required to identify another commercial partner.

Development of a Plasma and Neutral Beam Source for Semiconductor Processing

RTI Team Personnel: Stephen A. Lehrman

Problem

The semiconductor industry uses radiofrequency-generated plasmas to etch, that is remove or pattern, films on silicon, silicon compounds, photoresist, and aluminum in the fabrication of integrated circuits. As dimensions of the features approach the micron in size, as seen in VLSI chips, highly anisotropic etching is required. At the same time, the reduction in size of circuit components increases the likelihood of damage by energetic ions. Two important manufacturing requirements for a plasma etcher are a fast etch rate and high selectivity (i.e., preferentially etching some materials much faster than others). These requirements are a function of the plasma energy, flux, and gas composition.

NASA Technology

Since 1985 the Princeton Plasma Physics Laboratory (PPPL) has been involved in research with low-energy (2 to 10 eV) neutral atoms to study beam-surface interactions. Sponsored by NASA's Marshall Space Flight Center the goal of this work is to understand the physical and chemical mechanisms involved in the erosion of materials in low earth orbit. The successful development at PPPL of novel plasma and neutral sources for this research has suggested a number of technological applications in surface modification and semiconductor processing. As noted above, plasma devices are the basis of much semiconductor processing and the development of new and better sources is important to the industry. The development of the lower hybrid (LH) plasma source and the atomic oxygen source suggested their potential for industrial micro-fabrication or material modification. The most promising application is the use of an enhanced version of NASA's LH microwave plasma source for semiconductor processing. Another potential application is the use of reactive neutral beams (such as atomic oxygen) for charge-free stripping of photoresist and etching of semiconductors.

Participants

- Dr. Dennis Manos, Princeton Plasma Physics Laboratory
- Dr. David Richman, Sematech Center for Excellence in Plasma Etching at the David Sarnoff Research Center

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Status

The Marshall Space Flight Center TU Office has decided not to fund the project in FY92. Dr. Manos continues small collaborations with IBM-Essex Junction and AT&T Bell Laboratories. However, there are not sufficient funds this year to perform any new development. The white paper submitted to DARPA for their Advanced Lithography Program was not selected for funding consideration.

Action

The Applications Team will continue to maintain a current awareness of PPPL activity on this project.

Diagnostic Cystoscopy Display System

RTI Team Personnel: Daniel L. Winfield

Problem

Image acquisition, manipulation and display technologies are required to provide a single display of an entire hemisphere of the interior of the human bladder.

The use of fiber optic endoscopes has become increasingly important in diagnosing many conditions which previously required surgery for a confirming diagnosis. During cystoscopy the interior of the urinary bladder is inspected with telescopes which are long enough to reach the inside of the bladder and which provide an image at the ocular held close to the physician's eye. Both rigid and flexible cystoscopes are commercially available. These telescopes have lenses at their tip which provide varying field of view and angle of view. In general they produce a conical field of view ranging from 50-90° with this field of view oriented anywhere from zero to 110° from the long axis of the telescope. These cystoscopes enable the surgeon to obtain spot views of the interior of the bladder.

A method is sought to create a flat panoramic image of approximately one half of the bladder interior. This image would be understandable by the clinician and easily included in the patient's medical record for comparison with images acquired later in the course of the disease. The specific application of interest is in the diagnosis and monitoring of superficial bladder tumors which have a great tendency to recur.

NASA Technology

MSFC proposes developing a new cystoscopic system using a panoramic annular lens. MSFC has funded the University of Alabama-Huntsville to develop an endoscopic system using the panoramic annular lens to give panoramic annular views of the interior of pipes, etc. for inspection purposes. The PI feels he can reduce the lens diameter to 6.3mm thus making it feasible for a bladder endoscopic system.

Participants

- Dr. James Daughtry, Jupiter, FL
- Dr. John Gilbert, University of Alabama-Huntsville

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Status

The original problem submitter has since left the University of Florida and is not be in a position to lead this project. The American Cancer Society has identify another urologist, Dr. James Daughtry, to serve as clinical investigator on this project. Dr. Daughtry has met with the technology developers and is developing a proposal to ACS.

Action

RTI will assist the ACS and their PI in developing a complete proposal. If ACS wishes to pursue the project, we will work with MSFC to develop a revised project plan for the FY92 POP.

Encapsulated Cells for Hormone Deficiencies

RTI Team Personnel: John G. Cleland, Doris Rouse

Problem

Diabetes is a serious, chronic condition that affects about one in every twenty people in the United States. It is the leading cause of new blindness, the third leading cause of death, and accounts for 40,000 limb amputations per year in the United States. The American Diabetes Association estimates that the United States economic drain due to diabetes is about \$18 billion annually. Insulin injection therapy and strict diet are the primary approaches to treatment of diabetes. However, this does not prevent the secondary complications of diabetes since insulin injection cannot duplicate the precise feedback of functioning cell islets. The blood glucose levels of those on insulin therapy fluctuate significantly and often are excessively high (hyperglycemia). Prolonged periods of hyperglycemia are thought to lead to the long-term complications of the disease.

Other methods being investigated to replace the diabetic's insulin deficiency include implantation of insulin pumps or mechanical artificial pancreases. Transplantation of the pancreas is another possible solution. All these techniques have encountered major problems including difficulties in developing a biosensor to monitor the amount of insulin required, blood clotting, fibroblast overgrowth, overdosage, and rejection of transplanted tissues.

NASA Technology

NASA has supported microencapsulation technology and droplet formation research for potential applications ranging from calibration standards to phase change encapsulated materials to fusion energy conversion targets. Studies have involved basic droplet dynamics, fluid mechanics, potential approaches to materials development in microgravity, acoustic levitation, and particle coating. The potential of microencapsulation technology applied to disease treatment by transplantation of living cells in humans is extremely attractive. Cells of interest are enclosed within a semipermeable membrane and thus are protected from the "hostile" surrounding medium, including antibodies and cytotoxic factors, while allowing nutrients to pass freely through the membrane to maintain the viability and normal function of the enclosed cells. For diabetes, transplantation of encapsulated islets of Langerhans would be investigated. Langerhans are clusters of cells within the substance of the pancreas gland that are responsible for secreting insulin necessary to control the blood sugar levels in humans. This technology has been investigated by scientists

at the Jet Propulsion Laboratory working primarily in cooperation with the University of California Los Angeles (UCLA).

Participants

- Dr. Taylor G. Wang, Director, Center for Materials Research and Applications, Vanderbilt University
- Dr. Patrick Soon-Shiong, M.D., Director of the Pancreas Transplant Program, UCLA
- Dr. Robert Snyder, NASA Marshall Space Flight Center

Status

Dr. Wang submitted a proposal and project plan to the Office of Commercial Programs, NASA. The RTI Technology Applications Team further discussed the problem and solution with Dr. Wang and with Dr. Snyder at MSFC. The Team recently reviewed the proposal and provided comments to the NASA Headquarters TU Division. Funding in the second quarter of FY89 was approved as a grant award. Funding has continued through this quarter at a reduced level. Progress reports have been reviewed by both the Applications Team and by NASA Code C.

Applications Team member, Dr. John Cleland, and Ray Gilbert of NASA Headquarters, held a detailed teleconference with Dr. Taylor Wang, Vanderbilt University, on progress and planning for the Cell Encapsulation project. Dr. Wang and the team have met with researchers at the University of Toronto, venture capitalists from Boston and a law firm to plan further R&D and ultimate marketing. The technical status established that live cell testing would begin in about 18 months. Some related successes have been achieved at the Islet Cell Transplant Institute at UCLA. An annual report from the Vanderbilt researchers was delivered to the Applications Team.

Action

The Team will review the upcoming Project Status Report and confer with the NASA HQ Technology Utilization Office.

Enhancing Magnetic Resonance Images for Improved Cancer Diagnosis

RTI Team Personnel: Daniel L. Winfield

Problem

Proton magnetic resonance imaging (MRI) has very rapidly become the most significant imaging modality since X-rays because of its ability to image soft tissues due to their differences in magnetic relaxation behavior. However, there are many instances where the soft tissue contrast, within the individual images of the data set acquired, is not sufficient to allow the physician to make a differential diagnosis with an adequate confidence level (i.e., with sufficient sensitivity and specificity).

MRI systems produce spatial distribution estimates of several distinctive tissue parameters. These include proton densities, relation times, and flow phenomena. However, the full differential diagnostic potential of these images is currently diminished by several troublesome factors. These include:

- Breadth and overlap in the distributions of intrinsic parameter measurement values
- Instability of intrinsic measurement values
- Large volume of image data sets, especially for 3-D imaging techniques
- Inherent signal-to-noise limitations
- Instrumentation problems related to selective slice techniques, partial volume effects, radiofrequency attenuation, gradient field distortions, and antenna loading characteristics.

NASA Technology

The need to analyze and interpret remotely sensed multispectral data from orbiting satellites (i.e., images obtained at different frequencies) has given rise to a substantial technology in image processing and pattern recognition methods, such as the ELAS software developed by NASA. However, very few centers have successfully applied these methods to medical image analysis and interpretation.

The proposed method of attack therefore involves: (1) improved optimization of MRI imaging methods, (2) implementation of more rigorous image standardization and registration procedures, and (3) evaluation of several methods of multispectral feature analysis, and finally (4) their implementation on high-performance computer architectures such as artificial neural net systems (ANNS).

Participants

- Laurence Clarke, Ph.D., University of South Florida
- Bob Butterfield, Kennedy Space Center
- Doug Rickman, Ph.D., Stennis Space Center

Status

A press conference was held April 26, 1990 to make the joint award of grants from NASA and ACS to formally begin the project. The investigators have already shown, with a series of seventeen patients, that a neural network system can be a more accurate classifier than current technology. Progress has also been made in developing fuzzy logic methods of 3D image segmentation that requires no training sets. Match support has been received from Siemens (\$50K) and from Sun Microsystems (\$71K) in the form of an equipment gift.

Commercialization

Artificial Cognition System, Inc., has committed to contribute \$50K per year for the 3-year project. This will include provision of a state-of-the-art Neural Net System and support expertise in its use as well as actual financial contribution to USF. The resulting product should have significant commercial potential and will involve cost-effective additions to existing MRI systems and/or dedicated computer systems.

Action

Monitor project progress.

Flat Panel Displays

RTI Team Personnel: John G. Cleland

Problem

New techniques are sought for the production of full-color electroluminescent (EL) displays. Techniques are sought for improving EL phosphor performance and reducing production costs by reducing processing steps and increasing yield.

Flat-panel displays have recently received considerable attention from the technical as well as the popular press. Successful development of bright, full-color flat-panel displays would lead to the replacement of cathode ray tubes (CRTs) in applications ranging from aircraft cockpit displays to high-definition television (HDTV).

The aerospace community would like to replace CRTs with flat-panel displays because of their potential savings in volume, weight, power, reliability, and lifetime. Of their many potential advantages, the most important is their shape – they are flat and they can be placed where a CRT would not fit. In commercial markets, flat-panel displays are presently making a significant impact on microcomputer technology. However, reliable color displays are a critical need in this area. HDTV is a longer term goal, but there is considerable activity in Asia and elsewhere to develop flat-panel color displays for this potentially enormous market. Of several competing approaches, thin-film electroluminescence (TFEL or EL) is a strong candidate for use in flat-panel displays. Monocolor TFEL displays are currently available for portable microcomputers, and prototype full-color displays have been demonstrated.

EL color displays are far from ready to replace CRTs because the blue phosphor is not bright enough and current fabrication processes produce low yield. The brightness of blue EL phosphors and production yields are strongly related to the processes used to form the electroluminescent phosphors.

It is estimated that the consumer market for flat-panel displays will reach \$1 billion and the non-consumer market will reach \$2.1 billion in 1994. However, due to the resolution, response time, size, and viewing angle limitations present in flat-panel displays, CRTs will continue to control the display market well into the 1990s.

Full-color EL displays require phosphors emitting primary colors. In the present state-of-the-art, the preferred choices are the following:

- Red	ZnS:Sm ZnS:Mn (with a suitable filter)
- Green	ZnS:Tb
- Blue	SrS:Ce ZnS:Tm

Of the three primary colors that can be produced, red and green phosphors are bright enough and have strong enough chromaticity for immediate application. The brightness and chromaticity of the current blue phosphors, however, are far from adequate. Serium-doped strontium sulphide is fairly bright, but its color is an unsaturated blue-green; the alternate thulium-doped zinc sulphide (ZnS:Tm) has a deep saturated blue color, but its luminance is lower by an order of magnitude.

The weak EL performance of ZnS:Tm is inconsistent with cathodoluminescence and photoluminance measurements of this material, which indicate very strong emission in the deep blue. Thus, the low EL luminance is probably due to extrinsic causes that can be mitigated or illuminated. For example, energy losses of the EL-exciting electrons may be caused by excitations of impurities and by non-radiative transitions at defects. The presence of impurities and structural defects in the phosphor films is directly related to the thin-film EL fabrication procedure. There is strong evidence that some other techniques such as ion implantation of thulium (and the dopants for red and green phosphorous) into thin films of ZnS, can form bright EL phosphors and avoid problems of impurities and structural defects. Additionally, ion implantation, which is a direct line-of-sight process, offers the potential for forming the pixel patterns required for full-color flat-panel EL displays.

The leading competition and perhaps lead technology for flat-panel displays is liquid crystal display (LCD) technology. Active-matrix LCDs combine two technologies: thin-film semiconductors and flat-panel liquid crystals. Active-matrix displays yield high contrast, good color, and a wide viewing angle. They also preserve two of the most attractive features of LCDs: low power consumption, which means portability, and low voltage, which means they can be driven from TTL logic levels. The main technological problems with these two panels include the need to develop the capability to deposit on glass defect-free arrays of thin-film transistors or diodes and the need to obtain accurate registration of such arrays with the accompanying LC structure. Further complicating production is the fact that, in a color display, the number of pixels is quadrupled, and filters must be added with critical alignment.

Technology Constraints and Specifications

Critical objectives are to move electroluminescent displays into full-color displays with high luminescence. The RGB display must be designed to obtain both

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chromaticity and intensity values that strike the right balance of red, green, and blue. This balance is important to accommodate the varying sensitivity of the human eye to different wavelengths of color. Ten thousand hours of useful life is a goal designated for most flat-panel displays. Package thickness for flat-panel displays, which is typically 0.75 to 1.5 inches, varies from approximately 0.5 to 2.5 inches. A flat-panel display can be either AC or DC. An ultimate goal for resolution might be 640X640 pixels or an EG standard of 640X350 pixels. As stated, this will require a 1920X350 RGB display if translated from a monochrome display. EL area luminance must be increased in the first instance to match for example, such currently obtainable luminance numbers as 20 to 60 FL for plasma display panels.

Most of the latter constraints summarize long term goals. Near term, it is highly desirable to simply eliminate or greatly simplify some of the fabrication steps for EL such as chemical etching and separate phosphor deposition steps. Display cells must be fabricated, tested, and evaluated for each color.

NASA Technology

Exploratory tests conducted by investigators at NASA Langley Research Center indicate that ion implantation has a strong potential for introducing dopants into EL phosphor material. Under NASA sponsorship, many of these ions have been implanted into thin films of terbium-doped ZnS; optical tests on the ion-implanted EL phosphor showed a strong change of color from green to red-orange. This very preliminary result indicates that the implanted Mn ions were incorporated and optically activated in the ZnS host.

The RTI Technology Applications Team has contacted Dr. James Robertson at LaRC to discuss the advances made at that Center and to try to match interests with Spire Corporation and other possible commercial ventures. A white paper is being prepared by Spire Corporation in consultation with Dr. Robertson, which will be evaluated by the Team, the LaRC TU Office, NASA Headquarters TU and other experts.

Status

A project plan has been reviewed by the LaRC TU Office, NASA HQ and the Applications Team. NASA HQ recommended initial funding in FY90. A LaRC contract with Implant Sciences Corporation is being signed to transfer NASA developments and continue optimization of the phosphors. Good progress was demonstrated at the LaRC review last quarter.

Action

The Team will continue to assist LaRC TU Office as needed.

Improved Environmental Control for Closed-System Growth Chambers

RTI Team Personnel: John Cleland, Jeff Antley

Problem

Improvements for environmental growth chambers are needed in the areas of lighting, atmospheric control and analysis, leakage integrity, computer control, and microbiological monitoring.

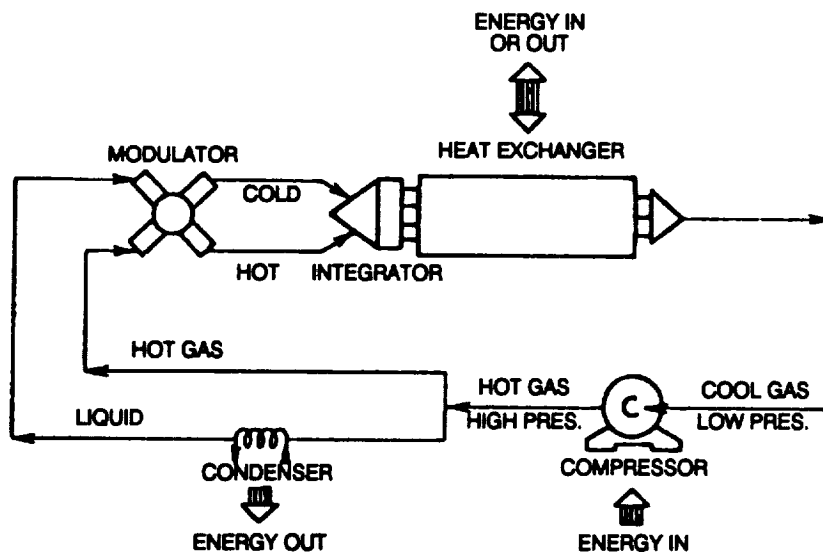
Environmental Growth Chambers (EGC), of Chagrin Falls, Ohio, is representative of companies involved in designing closed-system growth chambers, incubators, and dry boxes for use in botanical research, greenhouses, laboratories, and other applications. EGC desires emerging technology for application in their controlled environment chambers. Areas of improvement include lighting systems, atmospheric control and analysis, pressure control, computer control, integrity (or sealing), and microbiological monitoring.

There are two problems associated with lighting: current technology cannot provide spectral manipulation nor can it provide irradiance equivalent to two suns. Present lighting schemes impart excessive infrared radiation (wavelengths above 1000 nanometers), and the current maximum irradiance approaches one sun (the equivalent of daylight).

Environmental chambers currently do not control excessive carbon dioxide. Carbon dioxide levels increase in the absence of light, a problem for diurnal chambers and closed-loop systems. The ability to better simulate natural conditions would allow research into forest decline and similar problems.

In a closed-loop environmental system, internal pressure may fluctuate as a result of many factors, including excess heat from lighting elements. Pressure control could eliminate this side effect and provide better simulation of natural environments. For dependent variables such as pressure, which are affected by many other variables, expert systems are needed for sensors analysis and control.

Improvements in computer control of environmental states could come in the areas of real-time lighting and temperature manipulation as well as real-time mass and energy balances. A computer interface would allow complete interaction between human controllers and the chamber environments, with instantaneous information retrieval.



✓

NASA Technology

Currently, NASA's Ames Research Center is researching Controlled Ecological Life Support Systems (CELSS) as a means of providing food, air, and purified water from crop plants. Inhabitants of long-voyage spacecraft and interplanetary bases will be the beneficiaries of the CELSS studies.

The CELSS research is currently concerned with the development of the Crop Growth Research Chamber, which will be a closed system with separate recirculating atmosphere and nutrient delivery systems. There are two main components to the CGRC: atmospheric environment and hydroponic environment. New technologies must be developed to adequately control the chamber and to ensure its isolation from outside environments.

The conceptual design review of the CGRC occurred in November 1989, and construction of a prototype was to follow. These technologies have direct application to the problems that Environmental Growth Chambers has addressed.

Participants

- David Bubbenheim, NASA Ames
- A.O. Rule, Environmental Growth Chambers, Inc.

Status

The RTI Applications Team has met with NASA Life Sciences experts in closed environmental systems at both ARC and Kennedy Space Center. The Team has also met with Mr. A.O. Rule, President of EGC. The Technology Utilization Office at ARC has been consulted on project planning for FY90 and FY91. This project has been funded for FY91 and cooperative efforts are underway between ARC and EGC. The project's progress was reviewed by Dr. John Cleland during a visit to ARC in February, and in conversations with Ray Gilbert, NASA TU, and David Bubbenheim in this quarter. There is a potential for expanding the project using a newly available life sciences facility near ARC.

Action

A review meeting with Dr. Bubbenheim at NASA HQ is being planned for the next quarter. Co-funding from EGC and from NASA Code S will be sought to expand the project.

Improved Suspension for Wheelchairs

RTI Team Personnel: Daniel L. Winfield

Problem

A form of suspension is required which will dampen wheelchair vibrations during traversal of rough, uneven ground.

Users of both manual and powered wheelchairs can suffer discomfort when encountering accelerations in both the horizontal and vertical planes. These situations commonly occur when the user is forced to travel over rough, broken terrain. While special "all-terrain" wheelchairs have been built, we are seeking ideas for suspension designs applicable to conventional wheelchairs in use over moderately rough terrain, such as a farmyard.

The more obvious solution -- to place spring suspensions on the rear wheels of the wheelchair -- causes less obvious problems. The addition of a spring suspension improves comfort and reduces fatigue for the user, but the efficiency of the propulsion decreases due to excessive pitching. Pitching is particularly noticeable in manual wheelchairs because the input torque is periodic, not constant. In addition, tip-over stability is compromised due to a shifting of the center of gravity of the user-wheelchair system.

Ideas for wheelchair suspensions include shock absorbers, spring systems, four-point articulated systems, or seat suspension. Requirements for spring and damping mechanical elements are that they perform well in both the short-period and long-period modes.

Participants

- Bruce Weddendorf, MSFC
- Pete Rodriguez, MSFC

Status

RTI conducted a literature search and provided a number of articles on wheelchair and bicycle suspensions to MSFC. MSFC has developed a preliminary design employing the wheel rim as a composite spring to absorb shock in "overload" conditions. A project plan has been prepared. MSFC engineers are now conducting various dynamic analyses to test the design concept. RTI solicited comments from the University of Virginia and the National Easter Seal Society on the preliminary design.

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Action

Participate in the planned preliminary design review in October 1991. Based upon results of the review, solicit co-funding from NESS in 1992.

Long Duration Airpack for Fire Fighters

RTI Team Personnel: Stephen A. Lehrman

Problem

In certain applications, fire fighters need a longer duration breathing apparatus than that provided by commercially available compressed air bottles. These applications include fires in high rise buildings, subways, warehouses, basements, ships, airports, and hazardous material handling operations.

Fire fighters breathe compressed air when combating a fire in a closed environment. The compressed air bottles are rated from 30 minutes to 60 minutes. However, fire fighters' respiratory rates increase when they fight fires, resulting in depletion of compressed air bottles in half the rated time.

American Heat Video Service documented the Los Angeles First Interstate Bank Building Fire. This fire occurred on the twelfth through sixteenth floors of a high rise office building. It has been described as the worst high rise fire in Los Angeles history. One of the major problems cited by the Los Angeles fire department was that the fire fighters ran out of air and had to leave the fire to replenish their air supply.

KSC has developed a liquid airpack for their own use, which was shown on Part 2 of the American Heat Video and resulted in approximately a dozen calls to KSC requesting more information. Fire department chiefs in Boston, Washington, DC, and elsewhere, as well as some manufacturers of self-contained breathing apparatus (SCBA), have expressed interest in participating in a demonstration of the liquid airpack.

NASA Technology

The liquid airpack is an open-circuit, positive-pressure, on-demand system that is initially charged with 6 pounds of liquid air. The system carries the equivalent of 60 minutes (conservative estimate) of breathing air and weighs only 24 pounds. A comparable compressed airpack weighs 35 pounds.

The liquid air is cryogenically cooled to -317 °F at 150 psi and stored in a tank called a dewar. As the liquid air leaves the dewar, it passes through expansion tubes and changes to a gaseous phase. The air is then accumulated in an accumulator tank.

Tests have demonstrated that the air provided is cool and of sufficient quantity to ensure positive pressure within the mask, even during high rate work. Recently,

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KSC learned that by lowering the temperature of the breathed air to 38 °F, they can reduce the core temperature of the fire fighter. This is of benefit in reducing fire fighter fatigue.

KSC has developed the technology to mix large quantities (500 liters) of liquid air from liquid nitrogen and liquid oxygen. Liquid nitrogen and liquid oxygen are commercially available in most metropolitan areas, although liquid air is not. Therefore, the cryogenic mixing technology is as important as the liquid airpack technology.

Participants

- Don Doerr, Kennedy Space Center

Status

KSC received four proposals in response to its RFP for a study of the commercial feasibility of the liquid airpack. KSC procurement has decided not to accept any of the proposals. KSC plans to rewrite the statement of work and re-compete the study.

Action

The Applications Team will discuss with the KSC TU office whether or not to assemble an expert panel of fire fighting professionals to assess this project.

Management of Wandering Behavior

RTI Team Personnel: Doris J. Rouse

Background

The Management of Wandering Behavior is an interagency project supported by the Administration on Aging (AoA), the Veterans' Administration (VA), the National Institute of Aging (NIA), the National Institute of Disability and Rehabilitation Research (NIDRR), and NASA. A panel of experts on memory impairment and the aging population, as identified by the agencies, met on May 14, 1985. The result of that meeting was an agreement that the feasibility study should address the development of a memory aid device for wandering behavior in older persons. Since that time, RTI has completed a feasibility study.

Status

Technologies for the Wandering Notification device were identified at JSC. RTI provided support to JSC in the preparation of a project plan, statement of work, and RFPs for selection of the collaborating manufacturer. The RFP was issued by JSC in May 1987.

Five companies submitted proposals in June 1987. Doris Rouse participated as an advisor in the Source Evaluation Committee meetings at JSC in July and August 1987. Cortex Electronics of San Bernardino, CA, was selected as the contractor, and a contract was signed on December 1, 1987. Phase A, Engineering Design, was completed in May 1988. On June 20, 1988, Cortex Electronics and RTI briefed sponsoring Agency representatives, including the NIA Director, Dr. T. Franklin Williams, and the Commissioner on Aging, Carol Frasier Fisk. The sponsoring agencies transferred \$40K each to NASA for Phase B, Prototype Development, which began October 1988.

The manufacturer, Cortex Electronics, demonstrated the prototype system for home and institution to the sponsoring agencies on November 27, 1990. Cortex is now making the product more rugged and developing manufacturing facilities for production of the system.

RTI assisted JSC in the preparation of final project documentation.

Medical Ultrasound Calibration

RTI Team Personnel: Daniel L. Winfield

Problem

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 regulation 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 proposed to develop a measurement system based on the LaRC-developed electrostatic acoustic transducer (U.S. Patent No. 4,080,960). These devices are inherently insensitive to the phase on the acoustic wavefront, have broad-band response, and are capable of following the envelope of typical diagnostic imaging pulses. An accuracy of better than 4 percent is projected.

Participants

- Tom Yost, NASA LaRC

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Status

NASA LaRC is nearing completion of the prototype instrument which will be evaluated at the Hampton, VA, Veterans' Hospital. The RTI Team assisted by providing pertinent literature, establishing contact with NEMA and AIUM, and evaluating the commercial potential. We have supplied details on the electrostatic acoustic transducer and on the proposed project to FDA, NEMA and AIUM.

Action

LaRC has requested RTI to develop a commercialization strategy for implementation in early 1992 once the prototype has been tested. RTI will work with the above mentioned organizations and with private industry to develop the commercialization strategy.

Monoclonal Antibodies for Cancer Diagnosis

RTI Team Personnel: Daniel L. Winfield

Problem

It has long been known that certain patients with neoplasms exhibit abnormal levels of proteins and enzymes associated with the normal clot- dissolving mechanisms in the human body. Since 1981 several papers have been published that clearly show that certain cancer cells, particularly melanoma, secrete urokinase or tissue plasminogen activator. It has long been suspected that individual metastasizing cells must secrete urokinase or some other fibrin-dissolving enzymes in order to invade new (non- malignant) tissues. Until now there have not been any assays sensitive enough to distinguish urokinase from other types of enzymes, such as pro- urokinase, therefore, it has not been practical to screen patients' plasma, cells, or biopsied tissue to quantitatively measure secretion of enzymes by metastatic tumors. The use of specific antibodies to urokinase could be used by pathologists to identify those cells that are metastatic and actively invading tissue.

NASA Technology

Previous NASA flight experiments that separated human kidney cells into 33 different groups required the development of new monoclonal antibodies to different molecular forms of urokinase that are produced by these cells. Research sponsored by NASA at the Baylor College of Medicine has led to the development of a family of polyclonal antibodies that are reactive with only certain regions on the urokinase molecules. Selected monoclonal antibodies can now be developed and used to establish diagnostic tests for small numbers of human cells, tissue samples, and plasma from patients.

Participants

- Dennis Morrison, Ph.D., NASA-Johnson Space Center
- Steve Ganda, NASA Johnson Space Center
- Dr. M. Z. Atassi, Baylor College of Medicine
- Dr. Tod Johnson, Cytology Technology, Inc.

Status

A complete, three-phase project plan has been prepared, and Phase I is underway. Existing polyclonal antibodies were screened against very pure samples of the

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different molecular forms of urokinase. Specific clones that produce the best antibodies will be identified and cultured to large quantities to produce the best monoclonal antibodies (Phase I). These will be used to develop standard radioimmunoassay, enzyme-linked immunoassays, and fluorescent staining assays for accurately measuring plasma levels of specific forms of urokinase and to stain pathology tissue specimens of metastatic cells (Phase II). Once developed, these tests will be used to determine their value in diagnosis of metastatic potential of various types of cancer (Phase III).

RTI worked with the American Cancer Society to stimulate interest in this project. Despite this interest, the principals have not prepared a proposal to ACS.

Action

Monitor project progress.

Multichannel Flow Cytometry

RTI Team Personnel: Daniel L. Winfield

Problem

The technical difficulties in performing multichannel flow cytometry limit its usefulness in either clinical or laboratory settings. Technical improvements needed include improved signal processing for multichannel analysis of optical emission spectra, reductions in complexity, size, and numbers of optical sensors, simplification of sample preparation, and expert system software. The American Cancer Society-Florida Division expressed this need to KSC and RTI. RTI conducted further background research and located ongoing research and development work on these problems within JSC.

A new technology is needed to allow multispectral analysis of an emission spectra that may include overlapping spectra from several (up to five or six) fluorescent dyes. In addition, it would be desirable to use a single excitation light source rather than multiple lasers. Underlying all aspects is the need for the system to be user friendly in all aspects so that it may be used routinely in clinical and laboratory settings by staff with limited training in optical physics. This includes minimizing the complexity of setup and operation and simplifying sample preparation and may include the use of expert systems technology to assist operation as well as interpretation of data.

NASA Technology

Dr. Gerald Taylor of JSC contracted with the Los Alamos National Laboratory to investigate the feasibility of designing and developing a Flow Cytometer for Space Station with the following requirements:

- User (i.e., astronaut) friendly
- Minimum of five, preferably eight, channels
- Rugged but lightweight
- Modularity to facilitate performance upgrades
- Reduce size to 1 m³
- Safe, low-power light source
- Efficient handling of wastes and expendables.

Because these requirements are comparable to those for an earth-based clinical system, subsequent development will be directly applicable to a terrestrial spinoff.

Participants

- Dr. Gerald Taylor, JSC Life Sciences

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- Dr. David Robinson, ACS/University of Miami
- Dr. Mack Fulwyler, University of California - San Francisco
- Richard Thomas, RATCOM, Inc.

Status

The Advanced Flow Cytometry Workshop was conducted by RTI in Los Alamos, New Mexico, June 1-3, 1987. The Team was instrumental in preparing a proposal for ACS cofunding in the amount of \$301,000 over 4 years. In April 1988, the ACS executive committee approved funding for Tasks 1 and 2.

JSC conducted a workshop in Houston on May 31-June 2, 1989, to obtain final input from the scientific community on functional requirements and design specifications. ACS conducted a conference in November 1989 to focus on the application of flow cytometry to clinical oncology. Final input was received on the cancer application requirements. The RFP to build the prototype unit was released and proposals received in the first quarter of 1990. The contract has been awarded to RATCOM, Inc. A design review was held in January 1991 at JSC including ACS investigators. The current schedule calls for completion of the first instrument in January 1992. At that time, RATCOM will build a second unit for the University of Miami. ACS funding in the amount of \$101,000 has been approved for this phase.

Action

RTI will monitor project progress.

Object Definition and Image Correlation for Radiation Treatment Planning

RTI Team Personnel: Daniel L. Winfield

Problem

Image processing and image correlation technologies are required to aid radiotherapists in defining tumor volumes from multiple imaging modalities.

The National Cancer Institute Radiation Research Program has funded a Collaborative Working Group of three leading medical universities to develop sophisticated computer-based software tools for radiation treatment planning. These new tools should aid the clinicians by improving localization of radiation to tumors, lessening damage to normal structures and enabling more optimal selection of therapy.

This problem statement deals with the stage of the process wherein the clinicians attempt to determine the exact size, shape and position of the tumor relative to other anatomical features. To identify the tumor they use a variety of imaging modalities that, depending on the tumor type and location, may include computed tomography (CT) x-ray, magnetic resonance imaging (MRI), ultrasound, and radionuclide imaging. The process of defining the tumor volume is very time consuming as no current methods have successfully automated the delineation of the tumor, and there are numerous opportunities for errors resulting from artifacts specific to the different imaging modalities. Accuracy in defining tumor volume is very important so that the radiation dose to the tumor is maximized while sparing normal tissue as much as possible.

NASA Technology

Scientists at Stennis Space Center have indicated they may be able to apply image classification techniques in the ELAS software to this problem. They have supplied figures illustrating these methods to the problem originators.

Participants

- Greg Reese, Stennis Space Center
- Ed Chaney, University of North Carolina
- Sandra Zink, National Cancer Institute

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Status

The NCI Working Group met in March and requested Stennis to conduct a pilot study on a set of 30 CT images. This study will help determine if the image segmentation methods proposed do have benefit over current systems. Stennis has developed an estimate of \$12,000 for this pilot study; funds not available at Stennis at this time. RTI relayed this need for funding to NASA HQ. NASA HQ will determine availability of funding.

Action

Resolve funding issue.

Ozone Filtration

RTI Personnel: John G. Cleland

Problem

A method of manufacturing of an activated carbon catalytic "filter" with a low pressure drop which will remove ozone emitted from copier machines.

Copying machines can produce unsafe levels of ozone, especially if emitted in closed environments, e.g. copiers of facsimile machines operated on board aircraft. The environmental control standard for ozone in ambient air is 9 ppm. Activated charcoal is known to be very efficient in capturing ozone, but the applications of interest will not permit a bed or canister of charcoal to be used. The carbon should be configured in a flat filter geometry.

One solution is being marketed by a Japanese firm. This is a 3.22 inch by 2.35 inch rectangle with a flat weave of carbon fibers held by a .10 x .31 perimeter tape seal. The carbon is considered to be sintered into rigidity after being heated initially in a support matrix. This filter is costly, however, and a less expensive competitor is sought. The Japanese filter appears, on analysis, to contain metals/ions (including aluminum, copper, iron, magnesium, boron, nickel, and manganese in concentrations of less than 0.34%) which may act as catalysts, although for which reaction or sequence of reactions is not obvious. On the other hand, these materials may serve mainly to stiffen and strengthen the carbon matrix.

The RTI Applications Team has also been contacted by consultant, Mr. Arthur Brown, about a scheme for residential and commercial building filtration of organic materials using a carbon fiber matrix. The technique of manufacture is again a question mark for this application.

Technical Requirements

A flat ozone filter similar to that described is first required. Air flow through the filter is estimated to be 15.52 cfm. The concentration of ozone in the air to be cleaned is estimated to be 300 ppm on average. Pressure drop should be limited to 1.55 mm at the above air flow. The filter must be designed to capture the ozone for a period of six months before saturating or otherwise allowing excessive downstream concentrations.

It is considered that the main route to a lower cost product will be in manufacturing technique. New approaches to fabricating a carbon matrix in large volume (over 200,000 filters or 10,500 square feet per year). A better understanding of ozone

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removal, fixation, and/or conversion is also sought. Can all the ozone be converted to diatomic oxygen or are CO and CO₂ likely products and will these be held in the matrix or released? What is the efficiency of a thin filter likely to be?

NASA Technology

NASA has been involved with atmospheric ozone measurements for many years, including the recent evaluations of ozone layer losses near the Earth's poles. Experience with and design of measuring instruments may be useful in solving the problem.

NASA engineering designs for maintaining air quality in spacecraft and space habitats could provide insight into problem solution. Ozone sources associated with space flight would be of critical interest and any documentation of control techniques will be useful.

NASA expertise in fabricating carbon matrices is sought. Carbon composites have been studied for several years as insulating materials for spacecraft. NASA has been involved with the development of fiber composites such as Kevlar and Flexible Reusable Surface Insulation (FRSI) insulating blanket materials. LeRC scientists have developed new ion exchange membranes. Activated carbon is almost certainly a material examined by NASA for reducing volatile organics concentrations. Any experience with catalyst fabrication would be useful.

Status

Celeste Industries Corporation was recontacted in this quarter with further technical details. Carbon filtration experts at RTI are further reviewing the problem and making engineering recommendations.

Action

The Team will review to CIC and propose a plan of action toward project initiation.

Quantitative Measurement of Drooling in Children with Cerebral Palsy

RTI Team Personnel: Daniel L. Winfield

Problem

A simple device is needed to provide a reliable measurement of the volume of salivary overflow produced by children with cerebral palsy. A reliable measurement will aid in selecting appropriate therapy and in comparing the results of various therapies.

There are approximately 250,000 children in the United States with cerebral palsy and many more worldwide. Cerebral palsy is a diagnosis indicating that non-progressive damage has occurred to the motor area of the brain or that those areas have not developed normally. This damage leads to permanent motor disabilities. It is estimated that 10% of the children with CP have a significant problem with drooling, or salivary overflow. Drooling, in this context, results from poor oral motor control due to medical or developmental neurological impairments. Drooling is not just a social problem. Individuals who drool frequently have chronically chapped skin on the chin and neck and are at risk of dehydration due to the loss of fluids. Many of these children use electronic communication devices, and saliva can cause malfunction of these electronic devices. In addition, educational materials are frequently damaged. Another concern is the amount of time spent by speech therapists focusing on drooling rather than on facilitating speech development.

A variety of therapies are available including surgical, pharmacological, behavioral, and compensatory. Valid comparisons of these therapies are hampered by the lack of a convenient, reliable measurement to quantify the drooling problem. What is needed is a simple device that can be used in a clinic for one to two hours to test the individual for salivary overflow under controlled conditions.

NASA Technology

An engineer at Lewis Research Center has proposed a device for measuring the rate of saliva overflow. The method channels the saliva into a narrow tube, and, based on the viscosity of saliva, the height of the saliva in the tube can be correlated to production rate.

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Status

RTI has forwarded this concept to the United Cerebral Palsy Association for evaluation. Dr. James Blackman of the University of Virginia Visited NASA Lewis in February to review the need and the NASA concept. This has led to a revised concept by the NASA engineer.

Action

RTI will follow-up with NASA Lewis to document the revised concept and review this with UCP researchers. If the concept looks good, we will then pursue co-funding.

Robotic System for Greenhouse Automation

RTI Team Personnel: John G. Cleland

Problem

The University of Georgia Agricultural Engineering Experimental Station has initiated a program of robotized agriculture. One agricultural industry that contains many manipulation tasks requiring constant decision making is the nursery and greenhouse industry, which is extremely labor-intensive. Europeans have been responsible for most of the greenhouse automation efforts and creative new concepts in greenhouse design and management.

The University of Georgia, however, is examining several promising tasks, including grafting and budding, custom and selective harvesting, quality sorting, and transplanting. The first application for the University of Georgia Laboratory is the processing of geranium cuttings. This is being done with the cooperation of Oglevee Products, Inc., one of the largest United States greenhouse facilities for such processing.

Propagation of geranium stock proceeds in the following steps:

- Bring in tissue culture.
- Grow in pots, in a controlled, near-clean-room environment.
- Take cuttings and place cuttings in bags.
- Strip lower leaves, cut main stem, and put in rooting hormone in assembly line operation.
- Transfer back to greenhouse.
- Ship to growers.

It is anticipated that a robot will assist in the performance of steps 3 to 5, including such operations as trimming, stripping, and stem placement in trays.

The first requirement for this operation is to set up a machine vision system to locate the growing tip on the plants. This information is required to perform the functions mentioned and requires selection of the proper system development of controlled software and interface with the robot. Currently planned robot equipment for these functions is an ASEA IRB 1000 unit operating with a Heurikon HK68/V2f series computer for supervisory control. This is a VME bus, 20-MHz, MC68020/68881 system running Microware's OS9/68K operating system and using 1 Mb of local 60-nsec RAM.

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The University of Georgia is also very interested in developing an expert system to assist with the grading process in processing cuttings. This would be a knowledge-based system closely linked to the artificial vision feedback information and interfaced with direct operator control to compensate for any limitations in the capability of the expert system or supervisory computer. The University of Georgia would welcome NASA assistance in computer control programming, vision systems, expert system interfacing and control, and any other aspects of robotized processing related to the greenhouse processing problem.

Participants

- Dr. Ward Simonton and Dr. Brahm Versua, University of Georgia
- Oglevee Products, Inc.
- Mr. Max Sharpe, Mr. William Hill, Mr. Thomas Bryan; MSFC
- Mr. Russel O'Neal, Mr. James Montgomery, and Mr. Henry Phillips, Martin Marietta Corporation

Status

Some of the laboratory organization at the University of Georgia for supervisory controlled robotics research has been developed from a plan developed by Bejczy¹ at JPL. The RTI Applications Team discussed the problems with Dr. Simonton² and followed up with an initial contact at KSC where robotics are being applied for a seed planter related to an ecological life support system for the Space Station. The Team met with the MSFC TUO, NASA engineers and managers, and Martin Marietta Corporation on February 8 - 10 and March 30. Martin Marietta support to the project is being initiated through a Technical Directive. The MSFC TU office arranged a tour of NASA facilities. A project plan was submitted and first year funding received. An initial status report was forwarded by the University of Georgia to the RTI Team in late June 1989. A video and manuscript on the workcell was produced in early January 1990 by the University of Georgia. The force feedback gripper, a binary vision system, the manipulator, and controller have been integrated and demonstrated. This project's results were displayed at the Technology 2000 conference in November. A new contract from MSFC directly to the University of Georgia has been pursued during this quarter.

Action

The Team will contact the University of Georgia to review status and support requirements. The project plan for FY92 in terms of funding and results will be outlined.

References

1. Bejczy, A. K., "Control of Robotic Manipulators," *Handbook of Industrial Robotics*, Shimon Noff, Ed., John Wiley and Sons, NY, 1985.
2. Simonton, W., "A Supervisory Controlled Robotic System for Agricultural Automation Research," Paper No. 88-3027, Presented at the International Summer Meeting of the American Society of Agricultural Engineers, Rapid City, SD, June 26-29, 1988.

Video Screening System for Melanoma Detection

RTI Team Personnel: Daniel Winfield

Problem

This problem was presented by Dr. Arndt, Professor of Dermatology at Harvard Medical School. There are over 7,000 deaths per year from skin cancer, 75% of which are from melanoma. Early recognition is highly correlated with cure rate, as are lesion thickness and depth of invasion. Characteristic of melanoma are well defined, but early detection is complicated by the fact that many patients present with multiple (sometimes hundreds) of dysplastic nevi which must be monitored over time to look for signs of melanoma development. Frequent surveillance is required, and a video imaging system would be very useful for documenting lesions and recognizing early changes or development of new lesions.

NASA Technology

Jet Propulsion Laboratory has proposed a PC-based imaging system to first document potential melanotic lesions and to use digital image processing for comparison to previous images. The system will utilize image acquisition and processing technologies developed by JPL in its Earth and space sciences research program.

Participants

- Robert Selzer, Jet Propulsion Laboratory
- Kenneth Arndt, M.D., Harvard Medical School
- Clancy Beaudrea, M.D., Jacksonville, FL

Status

RTI has conducted a literature search and provided several pertinent articles to JPL, along with information on a commercially available, small field-of-view system for imaging individual lesions. JPL has identified Perceptive Systems, Inc. as a commercial partner on the project. FY90 and FY91 funding was reallocated to other projects, and JPL has elected to apply all FY92 TU funding to the Technology Affiliates Program. Thus, funding for this project is in question.

At the suggestion of RTI, Bob Selzer submitted a project statement to the American Cancer Society - Florida Division (on-going program with KSC). The ACS/NASA committee has met and requested a formal proposal from Dr. Arndt (with a

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Florida-based co-investigator) for co-funding the project. Dr. Arndt submitted the proposal to ACS, and a funding decision is expected by November 14.

Action

Attend November 14 ACS-NASA meeting on ACS funding decision. If ACS is positive, develop strategy to leverage this decision against other funding sources, including JPL, NASA HQ, and the National Cancer Institute.

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October 11-12, 1990: Doris Rouse and John Cleland traveled to Greenbelt, MD to participate in the GSFC TU program review and discuss with robotics engineers/managers new transfer projects.

October 12, 1990: John Cleland met with representatives from NASA HQ Code C, **National Institute of Corrections**, and the **U.S. Customs Service** to discuss details of a cooperative technology transfer project concerning drug detection and contraband control.

November 8-9, 1990: John Cleland participated in a full LaRC projects review with Ray Gilbert from NASA HQ. The review was held at the LaRC TU office.

November 9, 1990: Doris Rouse and Dean Hering traveled to GSFC for the Reconfigurable Module Manipulator System (RMMS) commercialization meeting. A strategy was agreed upon for commercializing the RMMS -- potentially benefitting the hazardous waste, manufacturing, construction and robotics industries.

November 12, 1990: Doris Rouse participated in the **Federal Laboratory Consortium Meeting** in New Orleans.

November 26, 1990: Doris Rouse participated in a meeting between NASA and the **American Diabetes Association** in Alexandria, VA to discuss collaborative Applications Engineering Projects.

November 27, 1990: The RTI Team organized a demonstration of the wanderer management system successfully completing the project. The manufacturer, Cortex Electronics, demonstrated to the co-funding agencies -- **Administration on Aging, National Institute on Aging, National Institute on Disability and Rehabilitation Research, Department of Veterans Affairs and NASA**.

November 27-28, 1990: The Team traveled to NASA's Technology 2000 conference in Washington, D.C. to support the NASA Centers and HQ. Important contacts were made with several commercial organizations and the Team made a presentation on the Applications Engineering Program.

December 10-12, 1990: S.A. Lehrman met with Arif Husain, Bill Callaghan, James Rooney, and Dan Diner at Jet Propulsion Lab regarding NASA Applications Engineering Projects.

December 11, 1990: S.A. Lehrman presented "The NASA Technology Utilization Program: An Overview" at the New Business Opportunities in **Drug Interdiction Symposium** in Los Angeles, CA.

SECTION 8.0: TRAVEL

December 11, 1990: Doris Rouse and John Cleland made a presentation on the Applications Engineering Program to Kevin Barquinero and other **Code M** staff at NASA HQ.

December 12, 1990: Doris Rouse met with Dr. Richard Kahn, Director of Research - **American Diabetes Association**, in Alexandria, VA.

January 3, 1991: Doris Rouse met with Dr. Richard Kahn, Director of Research for the **American Diabetes Association**, and a company developing a near-infrared glucose sensor to discuss a possible Applications Engineering Project.

January 10-11, 1991: Daniel Winfield attended a **NASA/American Cancer Society Meeting** at KSC to review current and new projects.

January 11, 1991: S.A. Lehrman and Tony Ratajczak (LeRC) met with Don Walukas and Dick Macon of the **National Center for Manufacturing Sciences** and Lou Toranatzky of the **Industrial Technology Institute** in Ann Arbor, MI.

January 14-15, 1991: John Cleland gave 2 presentations of the Team's applications projects activities related to corrections at the **American Corrections Association (ACA)** meeting in Louisville, Kentucky. At the invitation of the National Institute of Corrections, Dr. Cleland met with wardens, ACA executives and technical experts.

January 16, 1991: S.A. Lehrman met with Dave Hockman and Joe Montamerano of the **New Jersey Commission of Science and Technology** in Newark and Dr. William Langer of the Princeton Plasma Physics Lab in Princeton. The purpose of the meeting was to discuss the status of the applications engineering project to use the PPPL lower hybrid source for semiconductor processing.

January 17, 1991: S.A. Lehrman gave a presentation, "The NASA Technology Utilization Program: An Overview," to the **Public Service Electric and Gas Company** in New Jersey.

January 18-19, 1991: Dean Hering travelled to Kansas City to co-chair a special session convened by the Department of Education's **Center for Special Education Technology** at the 1991 International Conference on Special Education and Technology. During the session special education practitioners provided ideas and suggestions for problem areas being developed by a panel of special education experts and the Team.

January 27-30, 1991: S.A. Lehrman participated in the Thrust Area 5 panel on Technology Transfer from federal agencies to the construction and design industry at the **Civil Engineering Research Needs Forum** in Washington, D.C.

January 28, 1991: Doris Rouse met with George Masokowski and Bob Butterfield (KSC) and John Schoppman in Tampa, Florida to discuss the establishment of a **Space Medicine Institute**.

January 29-31, 1991: Doris Rouse participated in the Technology Utilization Officers meeting at Kennedy Space Center.

February 7-8, 1991: Daniel Winfield travelled to Washington, D.C. as a NASA representative to a Science Applications International Corporation **Expert Panel on Technology for Sensory Impairment**.

February 8, 1991: Dean Hering travelled to LaRC to meet with Joe Mathis, LaRC TUO, and to review technologies and projects at LaRC's Nondestructive Evaluation Laboratory.

February 11, 1991: Doris Rouse and Stephen Mangum met with Dr. Kay Scrimger and other staff at the **U.S. Conference of Mayors** to discuss technology transfer from NASA Centers to select U.S. cities.

February 11, 1991: S.A. Lehrman visited Ames Research Center and met with Geoff Lee to discuss the NASA Applications Engineering Program at Ames.

February 12, 1991: John Cleland traveled to GSFC to meet with Mr. Don Friedman, John Vranish and other technical experts on technology transfer in robotics.

February 15, 1991: S.A. Lehrman participated in a meeting at the **U.S. Occupational Safety and Health Administration** in Washington, D.C. on lead paint removal from bridges.

February 19, 1991: S.A. Lehrman, Frank Penaranda (NASA HQ), Ray Gilbert (NASA HQ), and Don Walukas (**National Center for Manufacturing Sciences**) met in Washington, D.C. to discuss joint technology transfer projects.

February 19-20, 1991: John Cleland participated in a televideo conference from MSFC with Gallaudet University, MSFC TU office, NASA HQ and Applied Research Corporation on the Emergency Vehicle Avoidance System. Cleland also reviewed projects with the TU Office.

February 20, 1991: Doris Rouse represented NASA at the **Interagency Committee for Disability Research** hosted by the National Institute on Disability and Rehabilitation Research.

February 21-22, 1991: Daniel Winfield travelled to Washington, D.C. to discuss technology transfer opportunities with Roger Powell and Dr. Faina Shtern of the **National Cancer Institute**. Also, discussions on the water-window x-ray microscope project with Dr. Houston Baker of the **National Center for Research Resources** were held.

SECTION 8.0: TRAVEL

February 27-28, 1991: Daniel Winfield travelled to MSFC to meet with the TU staff and project leaders for several possible new start projects.

February 28 - March 2, 1991: Dean Hering travelled to Albuquerque, New Mexico to participate in the **Utilities/Manufacturers Robotics Users Group (UMRUG)** meeting. Several utility and utility service representatives and the chairman of UMRUG, Harry Roman, were briefed on the TU program. NASA robotics, sensing and measuring technologies may potentially provide solutions to some of the utility needs. Follow-on contacts are being pursued.

March 1, 1991: Doris Rouse met with Frank Penaranda at NASA HQ to discuss the U.S. Conference of Mayors initiative.

March 19, 1991: S.A. Lehrman traveled to Charlotte, NC to attend the **Steel Structures Painting Council** meeting on Lead Paint Removal from Industrial Structures. At the meeting, Mr. Lehrman met with Lynn Rouse (TAB Industries), John Peart (US DOT), Ellen Ruznowski (OSHA), John Cignatta (Datanet Engineering) and Dave Hawk (Sverdrup).

March 20, 1991: John Cleland met with Mr. Geoff Lee (TUO Ames) to discuss Ames' POP responses and several projects involving the RTI Team.

March 21, 1991: Dean Hering travelled to the **National Agricultural Library** to participate with Ray Gilbert in the **Hardwood User's Requirements Committee Meeting**. Technical problems confronting the hardwood industry were discussed. The Team has provided materials to assist Dr. Chris Murdock in preparing defining documents which may be used to specify priority technology needs.

March 26-27, 1991: Doris Rouse met with Dr. Basil Pruitt and other burn surgeons at the **Brooke Army Medical Center Burn Unit** in San Antonio, Texas to discuss the LaRC burn depth diagnosis system.

April 1, 1991: Dan Winfield visited Ames Research Center to discuss current and new applications projects with the Ames TUO.

April 1-2, 1991: Dean Hering travelled to Tallahassee, Florida to participate in the **Florida Council High Tech Day**. Mr. Hering supported Kennedy Space Center in briefing interested companies on the NASA TU Program and technology opportunities at KSC.

April 3, 1991: Doris Rouse met with Ray Gilbert at NASA HQ to discuss status of Application Engineering Projects.

April 8-10, 1991: Dean Hering travelled to Williamsburg VA to present Technology Transfer: A Designer's Tool at the **Institute of Electrical and Electronic En-**

gineers (IEEE) Southeastern Conference. While at the conference, Mr. Hering presented the TU Program to several companies and NASA engineers.

April 19, 1991: S.A. Lehrman participated in **National Defense Manufacturing Technology Program, Task Force 4** meeting at the National Institute of Standards and Technology in Gaithersburg, MD.

April 22-25, 1991: Dan Winfield and Steve Lehrman attended the **Federal Laboratory Consortium** for Technology Transfer, Spring Meeting in San Diego, CA.

May 1-2, 1991: Dan Winfield and Doris Rouse attended the NASA TUO Program Review at NASA Headquarters.

May 2, 1991: Dan Winfield accompanied scientists from Stennis Space Center to the **National Cancer Institute**, Bethesda, MD, to discuss advanced image segmentation methods applied to medical diagnostic imaging.

May 6-7, 1991: Dean Hering and Steve Mangum travelled to Dallas TX to host a NASA TU exhibit and participate in the **National Center for Manufacturing Sciences (NCMS)** Annual Members Meeting. Mr. Hering and Mr. Mangum presented the TU Program to member companies and solicited corporate interests in upcoming joint NASA/NCMS workshops at NASA Field Centers.

May 10, 1991: Doris Rouse and Ron Lashaw participated in a committee meeting at NASA HQ to discuss documentation of spinoffs. Lashaw demonstrated the Spinoff Application Retrieval System (SOARS) database.

May 15, 1991: Dan Winfield travelled to Goddard Space Flight Center to participate in a video conference to discuss progress and plans for the Low Vision Enhancement System with representatives from SSC and Wilmer Eye Institute.

May 15-17, 1991: Dan Winfield gave a presentation of NASA technology transfer to a **National Cancer Institute Workshop** on Imaging-Guided Stereotactic Diagnosis and Treatment, Bethesda, MD.

May 29, 1991: Dan Winfield visited JSC to discuss application project opportunities with Charles Gott, Glenn Spalding, and Fred Grissom.

May 29, 1991: J.G. Cleland met with Peter Crimes, Director of Technology, **American Mining Congress**, at NASA HQ. Cleland, Gilbert, and Crimes discussed AMC interests and mechanisms for initiating cooperative efforts.

May 30-31, 1991: Dan Winfield moderated the **Limbs of Love Workshop** on Upper Limb Prosthetics at JSC.

June 10, 1991: Doris Rouse made a presentation entitled "NASA Technology Application Program" at the Technology Transfer Society Conference in Denver.

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June 19, 1991: Dean Hering travelled to Goddard Spaceflight Center to meet with Don Friedman (GSFC TUO), Ray Gilbert (HQ code CU), Kevin Barquinero (HQ code MT), Paul Masson (AmTech-JSR Program), and Karen Robbins (AmTech-JSR Program) to discuss commercializing the Capaciflector technology. Mr. Hering and Mr. Masson have initiated the first collaborative Joint Sponsored Research/Applications Engineering Project effort to commercialize the Capaciflector technology. The joint application of these two programs, which concentrate on technologies in different stages of research, on the Capaciflector will provide a model for future collaborative efforts and referrals between the two TU network elements.

July 10-11, 1991: Dan Winfield travelled to MSFC to discuss project plans for the X-Ray Microscope and the Wheelchair Suspension Projects.

July 18-19, 1991: John Cleland and Robert Wallace chaired a meeting between NASA GSFC TU Office and engineers, the **US Bureau of Mines**, Martin Marietta Corporation, and Joy Manufacturing to assess NASA-supported telerobotics transfers to the mining industry. RTI costs were covered by Martin Marietta.

July 17-18, 1991: Dan Winfield participated in the **NASA-ACS Scientific Committee** meeting at Kennedy Space Center. Mr. Winfield provided input on new projects under consideration and reported on the status of proposals being developed with NASA Centers.

July 23, 1991: Stephen Mangum and Doris Rouse met with the Mayor of Knoxville, TN and his staff, Ismail Akbay (TUO at MSFC) and Kay Scrimger (**U.S. Conference of Mayors**). The purpose of the meeting was to initiate a joint effort to transfer NASA technologies to meet priority needs of the City of Knoxville.

July 24, 1991: Stephen Mangum and Doris Rouse met with the staff of the Mayor of Houston, TX, Dean Glenn (TUO at JSC) and Kay Scrimger (**U.S. Conference of Mayors**). The purpose of the meeting was to initiate a joint effort to transfer NASA technology to priority needs of the City of Houston.

August 13, 1991: S.A. Lehrman met with Mr. Don Levine at the **U.S. Army Aberdeen Proving Grounds** in Maryland. The purpose of the meeting was to discuss NASA assistance in interferometric velocity measurement of projectiles from advanced rail guns.

August 13, 1991: S.A. Lehrman met with Dr. Howard Clarke of the **American Society of Mechanical Engineers** to discuss NASA's response to the problem statement concerning removal of non-ionic surfactants from metal working lubricants.

August 14, 1991: S.A. Lehrman met with Dr. Dick Willcens of the Delaware Technology Park in Newark to discuss the transfer of NASA composites technology.

August 21, 1991: A National Aerospace Plane (NASP) technology transfer meeting was held with representatives from NASA code C, the LaRC TU office, the USAF (Wright Patterson), NASA code R, and the NASP Joint Program Office.

August 25-26, 1991: Dean Hering travelled to Marshall Space Flight Center in Huntsville to facilitate a meeting between Mr. Bill Parker of Light Age Tech Labs and Dr. Tom Moore, Branch Chief of MSFC's Magnetospheric Physics Branch. Mr. Parker, Dr. Moore, Mr. Harry Watters of MSFC's TU Office, and Mr. Hering discussed contributions Dr. Moore's branch might make to assist Light Age in developing an Artificial Aurora display for several national museums that will accurately portray the current scientific understanding of auroras to teach museum visitors about the phenomena. Dr. Moore and Mr. Parker are currently discussing design possibilities.

August 28, 1991: Doris Rouse travelled to Washington, D.C. to participate in discussions with Len Ault and others regarding the documentation of NASA spinoff cases.

September 5, 1991: Doris Rouse met with Ray Gilbert, Arelene Kahn and Frank Penaranda to discuss plans for the Spinoff Benefits database and Application Team projects.

September 12-13, 1991: Dean Hering travelled to Houston to facilitate a meeting for discussing possible technologies developed for JSC that might help meet the needs defined in the Monitoring Medically Fragile Children in the Educational Setting Problem Statement. Researchers from NASA JSC and KRUG Life Sciences presented and demonstrated technologies to the Special Education Problem Statement Task Leader, a Biomedical Engineering Advisor from Texas Children's Hospital, and Fred Grissom from JSC's TU Office.

September 16, 1991: S.A. Lehrman and Dr. Charles Chiklis, a consultant to RTI, met with Dr. Michael Meador, Polymers Branch Chief at LeRC. The purpose of the meeting was to prioritize and plan commercialization opportunities for two NASA developed polyimides, VCAP and PMR-II-50.

September 17-18, 1991: Dan Winfield travelled to LaRC to discuss project status and develop commercialization strategies for the Medical Ultrasound Dosimeter and the Pulmonary Muscle Monitor.

September 23-25, 1991: Doris Rouse participated in the Technology Utilization Officers Meeting at LeRC in Cleveland, Ohio. At the meeting, Dr. Rouse made a presentation on the Spinoff Benefits database.

September 27, 1991: S.A. Lehrman participated in the American Society of Mechanical Engineers, Center for Research and Development, Technology Op-

SECTION 8.0: TRAVEL

portunities and Planning Committee Meeting. RTI's participation should provide the TATeam with opportunities to develop additional problem statements with ASME.

October 1, 1991: Doris Rouse travelled to Washington, D.C. to meet with Frank Penaranda and Code CU staff to discuss Applications Projects and RTI contract activities.

APPENDIX A: NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF

STAFF MEMBER	BACKGROUND	PROJECT RESPONSIBILITY
Dr. Doris J. Rouse	<i>B.A., Chemistry / Ph.D., Physiology</i> Fifteen 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.
Dr. John Cleland	<i>B.S., Aerospace Engineering / Ph.D., Mechanical Engineering</i> Seven years in NASA Technology Utilization Program. Twelve years' industry and U.S. Army research and management experience in process engineering.	Coordination of manufacturing and industrial projects. Areas of specialization include materials and robotics.
Stephen A. Lehrman, M.S.	<i>B.S., Mechanical Engineering / M.S., Mechanical Engineering</i> Four 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 machine design, precision engineering, and metrology.

APPENDIX A: NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF

STAFF MEMBER	BACKGROUND (continued)	PROJECT RESPONSIBILITY
Daniel L. Winfield, M.S.	B.S., <i>Engineering Analysis</i> / M.S., <i>Biomedical Engineering</i> Seven years in NASA Technology Utilization Program. Eight years experience in product development and manufacturing in the medical device industry.	Management of biomedical projects. Areas of specialization include ophthalmology and orthopedics
Stephen D. Mangum, M.P.A.	B.S., <i>Political Science</i> / M.P.A., <i>Master of Public Administration</i> Serving his fourth 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 a Program Analyst. Areas of concentration include organizational management, budgeting and finance, and data-base management. Assists project managers in background, marketing/industry studies and development of cofunding opportunities. Also serves as the Technology Utilization Network System (TUNS) supervisor for the Team.
Dean H. Hering, M.S.	B.S., <i>Electrical Engineering</i> / M.S., <i>Electrical and Computer Engineering</i> Over four years experience in electrical engineering, digital design, and neural networks.	Coordination of manufacturing and industrial projects. Areas of specialization include electrical engineering, digital design, and neural networks.

APPENDIX A: NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF*(continued)*

STAFF MEMBER	BACKGROUND	PROJECT RESPONSIBILITY
Robert J. Wallace	B.A., Environmental Design / M.S., Industrial Engineering Eight years in NASA TU Program. Ten years experience in CAD/CAM and automated factory simulation.	Coordination of manufacturing and industrial projects. Area of specialization includes automation and flexible manufacturing systems.
Jeffrey T. Antley	B.S., Aerospace Engineering Mr. Antley has served on the Team as a student intern for almost two years. Presently, he is a temporary staff member assisting in the areas of materials and electronics.	Assisting with background research and preparation of problem statements in materials and electronics.

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Author(s): Doris J. Rouse (Director-RTI)

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