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Annual Report

Covering the Period January 1, 1978 through December 31, 1978

TECHNOLOGY TRANSFER — TRANSPORTATION

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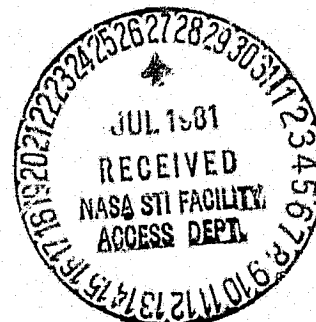
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SRI International



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EXECUTIVE SUMMARY

Introduction

The contributions of the National Aeronautics and Space Administration to the advancement of the U.S. technology base are broader, more complex, and in some cases more indirect than has been realized to date. Moreover, the number of NASA contributions that find direct nonaerospace application appear to represent only a small fraction of the large number of contributions that have advanced the state of technology in numerous other scientific fields.

This contribution has been made possible, in part, by the activities of NASA's Technology Utilization Office. This office has a demonstrated record of success in implementing and expediting the transfer of aerospace-derived technology for the solution of important technological problems in the areas of public transportation, housing, environment, and biomedicine. To assist NASA in achieving this transfer of knowledge, key research organizations throughout the country have established Technology Application Teams. These teams work actively in specified areas of public concern, helping to match problem and solution and following through to ensure the most efficient utilization of the transferred technology.

The SRI Technology Applications Team is primarily concerned with problems of the transportation industry. Members of the team routinely work with a user community including representatives of the Department of Transportation (DOT), the railroad and rapid-transit industry, and state highway departments, to name a few. In addition, team members maintain active contact with NASA's scientific community and continually strive to bridge the gap between key technological needs of the user and the available technology or expertise at NASA. This report presents in detail the activities carried out during 1 January 1978 through 31 December 1978.

Highway Problems

Selected highway-related needs for which the SRI Team not only identified applicable NASA-derived technology but also actively pursued the implementation and commercialization of that technology included: the near transfer of a novel, more effective highway crash cushion (the application of lunar landing technology); further applications of NASA's corrosion-resistant paint to meet highway/bridge corrosion problems (this technology has now reached the transfer stage and will no longer require Team involvement); the direct transfer of NASA corrosion protection expertise to meet the needs of the Golden Gate Bridge District (by involvement of key ARC personnel to solve a cathodic protection problem facing the

Golden Gate Ferry system); the application of a reformulation of NASA's zinc-rich paint for bridge deck protection--a problem national in scope and interest; the transfer of NASA's technique for soil moisture analysis to the Texas Department of Highways for its evaluation and use; and the completion of a number of problems (highway skid tester, for example) for which SRI Team activity is no longer warranted.

In the highway area, a market survey on impact attenuators was completed. The survey report describing the market for NASA/JPL's crash cushions was disseminated to all State Highway Departments.

Railroad and Rapid-Transit Problems

In an attempt to instill more rigor and interest in this program area, the SRI Team devoted considerable effort to the identification and validation of a number of new problems. Many of these problems will be addressed in 1979, including: the identification of technologies that would either prevent coal from freezing in hopper cars, or those which would facilitate the release of coal frozen in these carriers; the introduction of possible new rail/tie fastening technologies; and the examination of NASA materials and structures technologies to determine their applicability to the railroad and rapid-transit industries.

Specific problems addressed by the SRI Team included: grade-crossing train detection systems (to introduce new, more effective detection systems that would reduce the current level of accidents and fatalities); the near transfer of JPL's fire-resistant cable cover technology to an industrial wire and cable producer; and implementation of a systems assurance program for the Metropolitan Dade County rapid-transit system.

In addition to these activities, the SRI Team completed a detailed audit of NASA's contribution to the FRA/AAR's Track Train Dynamics Program. This audit detailed past NASA activities in the area and suggested further areas for NASA/DOT (FRA) cooperation.

Other Transportation-Related Problems

Additional transportation-related activities of the team included follow-on and liaison with the Donaldson Company, Minneapolis, Minnesota to assist them in the development of the LRC segmented liner (as required). In addition, the Team prepared a market survey entitled "Aerodynamic Drag Reduction Devices in the Trucking Industry." These reports will be distributed to our trucking contacts for their information.

Law Enforcement/Public Safety

Law enforcement/public safety efforts during 1978 concentrated mainly on problem identification and problem validation. The corrections (prisons) area appears to have a strong potential for the widespread use of

NASA-derived technologies that would benefit a large segment of the population both in and out of prisons. The Team will pursue the solutions to many of the problems presented in 1979.

Special Studies

At the request of Ames Research Center, the SRI Team prepared two reports. One report, entitled "Suggested Approach for a Rehabilitation Information Service in the State of California," outlines the needs of the State of California Rehabilitation Services Administration and suggests possible NASA solutions (or input) to this need. The other report, entitled "Purkinje-Image Eyetracker," was written to enhance the level of awareness of the eye research community of the developments in this field, sponsored under NASA funding at SRI.

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I INTRODUCTION

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I INTRODUCTION

The National Aeronautics and Space Act of 1958 established as a prime NASA goal the "widest practicable and appropriate dissemination of information concerning its activities and the results thereof." The mission of NASA's Technology Utilization (TU) Office is to ensure that NASA meets this goal. In the performance of this mission, the TU Office has organized its activities on a nationwide basis to promote the effective use of the vast amounts of new technology and other technical information generated by the space program.

The transfer of technology usually does not occur spontaneously. The diffusion of new information is a slow process; if it is not handled in a capable manner, it may never occur. To assist the TU Office in transferring technology in the most expeditious manner and to ensure its proper utilization, a number of key research organizations within the United States have established Technology Applications Teams. These teams, working closely with NASA research scientists and technology utilization specialists, identify solutions derived from NASA technology. It has long been shown that the active approach to this transfer of technology, or active problem/solution matching, as embodied by the team concept is the most effective tool for the dissemination and promulgation of advanced concepts and devices.

SRI has established such a Technology Applications Team with transportation and public safety as its main areas of concern. Members of the SRI Team during this report period were: Dr. Tom Anyos, Director; Ms. Ruth Lizak, Associate Director; Mr. James P. Wilhelm, Associate Director; Dr. Lo F. Christy; and Ms. Gail Kelton-Fogg, Research Analyst. Consultation and technical assistance were available to the core team from Mr. Dominic A. Guidici, Management Consultant; Mr. Clark D. Henderson, Senior Staff Scientist, Transportation; and Dr. Joseph H. McPherson, Senior Behavioral Psychologist. In addition, the core Team drew on other members of SRI's scientific and technical staff for solutions or commentary on specific technical problems. This interdisciplinary capability has allowed the Team to match widely varying areas of public concern outside the Team's direct expertise to relevant NASA-derived technological solutions.

In its effort to seek solutions to problems in the area of public transportation and safety, the SRI Team has developed a number of techniques and methodologies for decreasing the time gap between the development of a new technology and its commercial availability. Thus, the Team has been able to influence positively the movement of newly developed technologies across industrial, interdisciplinary, and regional boundaries. Highlights of this work are reported here.

In addition, in 1978 at the request of ARC,* the SRI Team prepared a special study for the Rehabilitation Services Administration, State of California, entitled, "Suggested Approach for a Rehabilitation Information Service in the State of California." Excerpts from this report may be found in Appendix B.

*The list of codes and abbreviations is provided in Appendix A.

IT HIGHWAY PROBLEMS

A NOVEL HIGHWAY CRASH CUSHION

Fixed appurtenances, such as bridge piers and abutments, heavy sign supports, retaining walls, and the like, existing along the nation's highways, present serious hazards to the wayward motorist or the occupants of an out-of-control vehicle. To reduce the severity of collisions with these objects, highway departments have installed impact-attenuating systems of sand-filled plastic barrels, steel drums, water-filled plastic tubes, frangible tubing, rubber tires, or crushable cannisters. Installed systems are expensive and difficult to maintain, however, and after a collision, the highway may be strewn with sand or water and thereby create possible new hazards.

The SRI Team believed that NASA's experience with impact-attenuating devices for extraterrestrial landings could be applied to the highway problem. Of particular interest was a concept (Tech Brief 72-10712) developed at NASA's Jet Propulsion Laboratory (JPL) wherein a large number of contiguous cylinders, arranged in multiple strata, would slow an impacting vehicle by sequentially crushing. The impact force would be dissipated in a controlled manner for smooth vehicle deceleration.

A program based on this concept was initiated in 1975 to develop a safe crash cushion. Various materials and configurations were comparison-tested for energy-dissipating characteristics; these materials included glass, steel, aluminum, polypropylene, and polyethylene.

For both performance and cost benefits, metal appeared to have the greatest potential application. In addition, it was determined that the same amount of energy dissipated by crushing a 55-gallon steel drum could be dissipated by crushing an array of 325 beverage cans of one-third the volume at the same cost and considerably lower g-levels.

Two full-scale impact tests were conducted successfully early in 1977, one at the JPL facility and the other at the California DOT test track. The first crash barrier cans crushed sequentially when impacted head-on at 28 mph, the second one at 38 mph. The average g-level was 4.5, which is considerably lower than the 12.0 limit set by the FHWA. Damage to the vehicles was minor--almost unnoticeable in the first test at 28 mph. Only the first two modules of the six-module system were damaged.

Reports covering the test at the California DOT track were prepared by the California engineers as well as by the JPL innovator, Albert C. Knoell. Both reports concluded that the energy-absorbing properties of the crash cushion were good, but that some redevelopment should be considered--the possible use of redirectional panels, for example. In

addition, it was recommended that further tests should be performed in accordance with NCHRP Report No. 153, "Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances."

A market analysis was conducted by the SRI Team, and the results were prepared for publication. It indicates that a 24-ft long crash cushion of beverage cans, meeting NCHRP requirements, can be produced for less than \$3,000 and installed for another \$1,000. (Currently available systems of the same size range in price from \$8,000 to \$22,000.) A 4-ft long, one-module cushion, also meeting NCHRP requirements, should cost about \$200 as compared with costs as high as \$8,000 for current systems of similar size. A potential 10-year market for 50,000 systems (\$6.5 million) is forecast, with a 1,000-system-per-year market for replacements (\$3 million per year).

Because large costs for repairs and routine maintenance can offset low initial costs, they are a prime consideration in crash cushion selection. Projections made by the SRI Team indicate that the NASA cushion's repair and maintenance costs are comparable to those of other systems, as shown in Table 1. The total 10-year cost for installation, repair, and maintenance for the NASA cushion is almost \$2,500 lower than that for any other cushion.

Table 1
COST COMPARISON OF IMPACT ATTENUATORS

Device	Average Bid Price + (dollars)	Average Repair Cost × (dollars)*	Hits per Unit	Repair (percent of Bid)	Total Cost (dollars)
Sand barrels	5,000	870	10	17.4	13,700
Water-filled sandwich system	17,500	212	10	1.2	19,620
Vermiculite concrete cannisters	17,500	358	10	2.0	21,080
Steel drums	9,000	839	10	9.3	17,390
NASA beverage-can system	4,500	683 [†]	10	17.4	11,330

* Based on California DOT data (1970-1977).

[†] Arbitrary use of highest percent for other systems (17.4%), less \$100 salvage, although SRI reviewers believe 15% is more realistic.

The market analysis conducted by the SRI Team indicated that trees and utility poles were the largest contributors to roadside accidents. Some of these obstacles may be removed; most will not. The Pennsylvania DOT, for example, has a need for hundreds of small crash cushions to protect vehicles on its winding rural roads from colliding with trees and utility poles.

Tests of these smaller crash cushions were conducted at Orange County Raceway later in the year. These tests were conducted at approximately 15, 20, 30, and 35 mph using a 4,600-lb vehicle and a live driver. Because of the live driver, the test speeds are being increased in small increments. In the first three tests, a 4-foot long cushion was impacted. A 6-foot cushion was used in each of the last two tests. All impacts were made at a 15° angle, a difficult test. The vehicle was instrumented for all tests, and the driver's helmet was instrumented for the last two tests (see Figure 1). The resulting g-levels were as follows:

Test No.	Vehicle		Helmet	
	Initial Peak (g)	Average (g)	Initial Peak (g)	Average (g)
1	7.6	2.0		
2	5.2	1.7		
3	7.6	2.0		
4	5.9	~2.0*	3.5	~1.0*
5	6.1	~2.0*	4.0	~1.0*

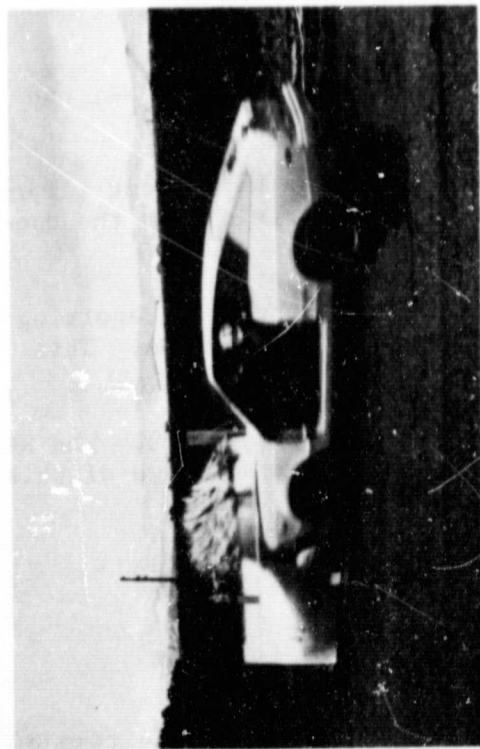
An average peak of 12g for the vehicle is acceptable by the FHWA; however, 8g is preferred.

The DOTs of both California and Pennsylvania are being kept informed of test details and results. Pennsylvania plans to field test the one-module system next year.

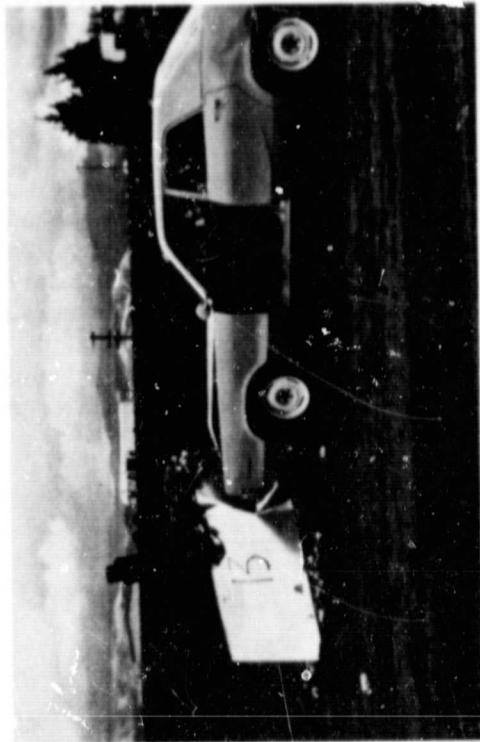
Copies of the market analysis, prepared during the last reporting period, were sent to 30 state highway departments and the FHWA. This was done in response to their requests.

Testing is expected to be completed in calendar year 1979. The SRI Team will actively seek commercialization and wide-spread usage of this technology.

* SRI estimate; average levels were not determined by JPL at the time of this writing.



(a) A TYPICAL IMPACT



(b) AFTER IMPACT — VEHICLE AND CUSHION



(c) CRASH CUSHION AFTER IMPACT



(d) DRIVER WITH INSTRUMENTED HELMET

FIGURE 1 TYPICAL IMPACT SCENES

NASA'S SUPERIOR CORROSION PROTECTION COATING

Corrosion engineering studies have found that because of exposure to salt spray, coastal bridges require more corrosion protection than inland bridges. Currently available coatings provide protection for about 20 years on inland bridges, but less than 10 years of protection on bridges near the coast. In a 1969 California DOT study, for example, it was reported that a coating with a 25-year lifetime inland would last only 4 to 6 years on the coast.

Most current anticorrosion coatings for bridges and other structures consist of zinc or aluminum dust that is mixed with and suspended in an organic or inorganic binder during application. Preparation of the final coating formulation is done on site and is somewhat complex. Rising labor costs have induced the transportation industry to seek a long-lasting, more easily applicable coating.

A search of relevant NASA literature revealed that a zinc-rich coating utilizing a potassium silicate binder, developed at GSFC and reported in NASA TSP 70-10060 and U.S. Patent 3,620,784, may provide suitable corrosion protection. Under laboratory conditions, the durability and adhesion characteristics of this GSFC coating proved superior to most commercially available zinc-rich inorganic coatings. Unlike these systems, the GSFC coating is especially easy to mix and requires no straining before application. The product should provide savings in labor hours as well as material costs.

The GSFC coating is currently being tested on several coastal structures, on road equipment in the northeastern United States (as undercoating to protect against deicing salts), and on other structures exposed to high corrosion conditions. At this time, four variations of the potassium silicate binder have completed qualification testing in accordance with military specification MIL-23236 (ships). The variations, which simplify preparation and thus ensure batch repeatability, have been documented in a new patent disclosure, NASA Case No. GSC-12,303-1. Tests thus far show the NASA coating to be durable, inexpensive, and easily prepared.

Testing of the GSFC coating by NASA's Materials Testing Branch at KSC has been completed. The summary report concludes that the coating is "equivalent to the best commercially available inorganic zinc-rich coatings in atmospheric corrosion resistance, abrasion resistance, and heat resistance."

Several well-established manufacturers have expressed interest in the GSFC coating and are considering the possibility of adapting the basic formulation to specific markets with the objective of patenting the

adaptions. This approach has obvious advantages for the manufacturers and may be advantageous to NASA also by promoting widespread use. The latest formulations appear to have additional advantages such as the ability to adhere to hot welds. Appropriate field tests are being conducted by the manufacturers.

The GSFC coating may receive further approval. It is being considered for inclusion in the NCHRP Project 4-14, "Coating Systems for Painting Old and New Structural Steel."

As the coating has reached the commercialization stage and continues to prove its superiority to competitive systems, SRI Team effort is no longer warranted. The transfer is therefore declared to be successful and complete and will no longer be a topic for team activity.

CORROSION PROTECTION FOR MODERN VESSELS

The U.S. National Electrical Code requires that docked vessels be properly grounded whenever commercial electrical power is used on board. In California, an unexpected side effect of grounding the Golden Gate Bridge District's aluminum-hulled ferries (see Figure 2) has been a significant increase in corrosion below the waterline. Although devices to stop this type of corrosion are commercially available, none has been approved by the U.S. Coast Guard.

In response to a request by the SRI Team to investigate the problem, Mr. Ernest Iufer of ARC made an in-depth tour of the ferry facilities and a ferryboat during May 1978. He concluded that if the materials used in the dockside ground rods were to be changed from iron and copper to a material that closely matches the electrolytic-solution potential of the ferries, then the galvanic current in the ground system would be reduced to negligible values. This in turn would solve the electrolytic corrosion problem.

Grounding systems using nonferrous alloys are not in common use but are permitted by the National Electrical Code. It was suggested that aluminum alloy AAA-5086 be considered for the dockside ground rods. This alloy contains 4.9% magnesium and 0.5% manganese and is well suited for marine use. A properly designed rod of this material will outlast iron in a marine environment. Approved connectors for attaching the copper ground lead to aluminum are commercially available.

The Golden Gate Bridge, Highway, and Transportation District was well pleased with the prompt and cost-effective solution provided by NASA, particularly since it had exhausted normal industrial sources of information before contacting the SRI Team. Plans are currently under way to install the proposed nonferrous grounding system. If the system performs as expected, it will be a real tribute to NASA expertise.

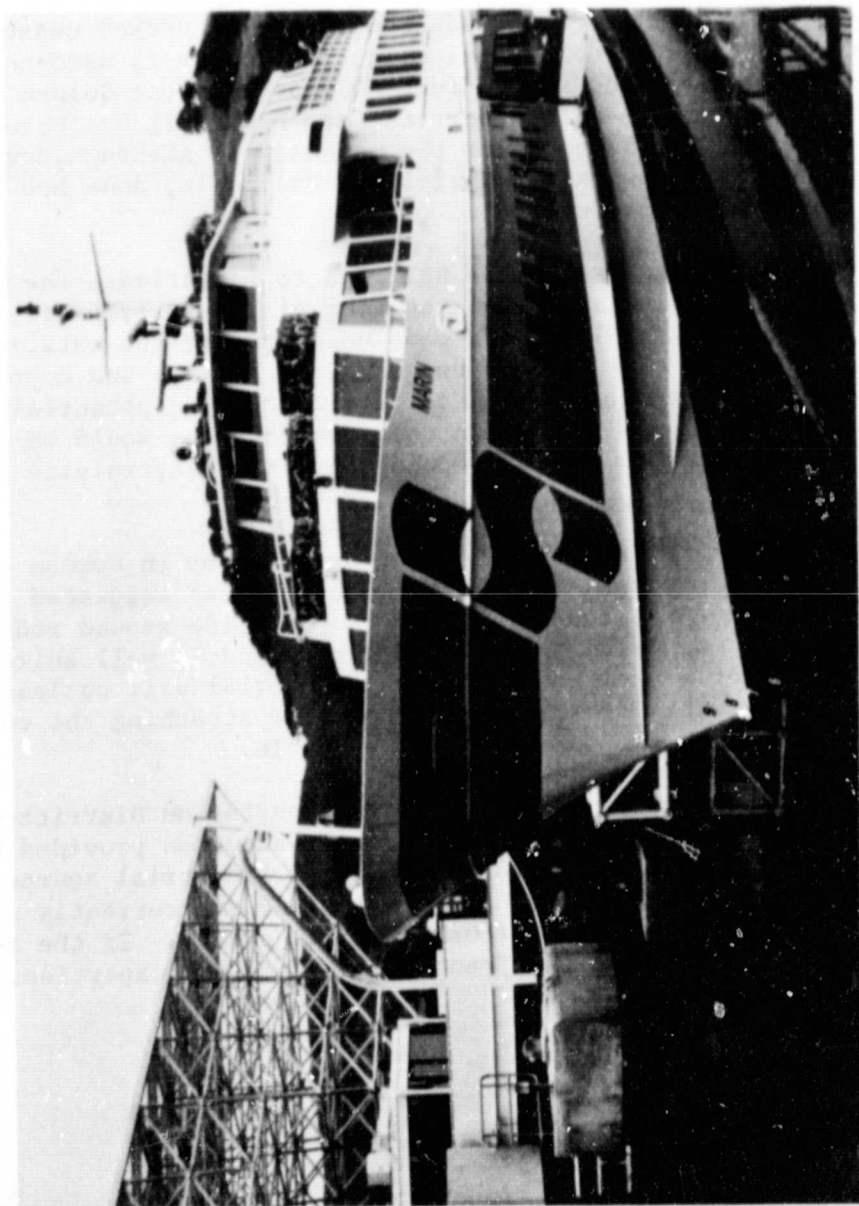


FIGURE 2 AN ALUMINUM-HULLED FERRY AT DOCKSIDE

UPDATE ON OTHER HIGHWAY PROBLEMS

Bridge Deck Protection

Background

Deicing chemicals containing chlorides have been shown to cause deterioration of concrete bridge decks. Highway departments have attempted to solve the problem by using waterproof membranes to deter penetration of the corrosive agent. However, if all chloride-contaminated concrete was not removed, the corrosion process continued. In some cases, it was actually aggravated because the membranes prevented the flushings and dryings that could reduce chloride concentration and prevented visual examination of the deck. Repair of these decks costs millions of dollars each year.

The NASA Technology: A Low-Cost Inorganic Coating

Source: Goddard Space Flight Center, Greenbelt, Maryland

The NASA-GSFC alkali-metal silicate binder (Case No. GSC 12, 303-1) that was developed for corrosion protection of steel has been adapted for use on concrete. Preliminary tests indicate that the potassium-silicate binder, when diluted and applied under pressure, penetrates the concrete, and the potassium ions neutralize the chloride ions. The binder has a high mole ratio of silica to potassium oxide (5.3:1). A coating of the undiluted binder (7 lb/gal) and a small quantity of zinc dust and Ferro-phos (6.5 lb/gal) is then sprayed on the surface as a sealant.* This treatment promises to provide a very cost-effective solution to the problem of bridge deck deterioration resulting from salt corrosion and perhaps of concrete bridge piling corrosion also.

While attending the annual TRB meeting in January 1978, the SRI Team met with representatives of the FHWA and the Oklahoma DOT, which have ongoing programs to safeguard bridge decks. The GSFC coating description was well received, and a tentative plan was made for the transfer of this technology.

To confirm the applicability of the GSFC coating for concrete protection, tests on concrete will be conducted following FHWA test procedures (FHWA-RD-77-85, "Sampling and Testing for Chloride Ion in Concrete"). Inquiries made by the SRI Team revealed that Caltrans researchers have tentatively agreed to apply the coating to a bridge deck section if the coating with its 6.5 lb zinc dust performs well during an accelerated test.

* Ferrophos is the registered trade name of $\text{Fe}_3(\text{PO}_4)_2$ for the Hooker Chemical Company.

Recent Activity

Accelerated tests were initiated at the San Francisco-Oakland Bay Bridge. For these laboratory tests, the GSFC binder was combined with seawater, salt water (3% brine), and tap water in quantities of 1.5 fluidrams per gallon, and a corroded rebar was submerged in each solution. Examination after 1 month revealed that the pH level had risen in all cases and the rebars' rust had been removed. The rust removal may be an indication that the potassium ions are migrating to the steel as expected. As an added benefit, this rust removal will prevent cracking of the concrete. That is, the binder not only will prevent further corrosion, but also will diminish some of the existing damage.

Tentative arrangements have also been made to have tests on concrete conducted by a commercial laboratory in accordance with FHWA-RD-77-85. Four tests are planned at a cost of \$200 each.

At Morton Chemical Company, a prospective manufacturer of the NASA-GSFC coating, concrete coated with the low-zinc formulation, is being compared with epoxy- and urethane-coated concrete. The SRI Team will maintain a low-level, liaison role during the commercialization of this technology in 1979.

Soil Moisture Analysis for Highway Construction

Background

Public works and highway departments have an immediate need for a rapid, accurate, and inexpensive technique for measuring soil moisture before road construction begins. Proper compaction of the road bed to prevent road collapse depends on accurate moisture measurements. Current techniques are either slow (overnight drying in an oven) or can handle only very small samples. Because most soil samples are heterogeneous and may contain large, agglomerated particles, small sample measurements are inaccurate.

The NASA Technology: Gas Chromatographic Moisture Analysis

Source: Ames Research Center, Moffett Field, California

A simple and rapid analytical technique for the analysis of moisture content of soils has been developed as part of the Viking and post-Viking studies at ARC. This technique entails extraction of moisture from a soil sample by means of a solvent that is subsequently analyzed with an inexpensive dedicated gas chromatograph (GC).

A rugged portable GC unit has been built for speedy (less than 1 hour) on-site analysis of soil. Initial tests have been conducted by Santa Clara County (California) public works personnel. Moisture measurements made by the NASA GC technique were compared with those obtained by oven drying.

Although the soil, a clay with rocks up to 1 in.³ in size, is considered by the FHWA to be difficult to analyze, no problem was encountered using the NASA technique. In fact, readings with 99.8% repeatability were obtained.

Evaluation of the technique is being continued in cooperation with the FHWA Fairbank Research Station. Of particular interest is the technique's capability to handle large samples.

Discussions have been initiated concerning the manufacture of a GC kit (including an 11-lb recorder, an integrator, pint-size bottles, needles, and a gas tank) for use by highway personnel. For the entire 40-lb kit, a price of a little over \$1,000 has been estimated. A survey of other manufacturers of simple gas chromatographs revealed a price range of \$1,000 to \$4,000 for the GC alone, none of which is built for field use.

Recent Activity

Because of a heavy work load, NASA-ARC innovator Glenn Carle will be unable to complete his analysis of soil samples supplied by the FHWA. In an attempt to overcome this transfer barrier, the SRI Team sought other assistance. As a result, Texas DOT personnel are giving consideration to finishing the tests and analyzing the data in their laboratory. This activity is expected to be completed in calendar year 1979. If the results of these efforts are as promising as expected, the FHWA may disseminate the information regarding the technique to all 50 states.

An Inexpensive Highway Skid Tester

Background

Techniques for noncontact measurement of roadways have been of interest to highway and railway engineers for several years. Early attempts at road profiling used a test vehicle with an independently suspended fifth wheel. As this wheel, linked to a stylus and recording chart, encountered irregularities along the roadway, it would map the surface (or profile) of the road. Because this method relied on a mechanical link between wheel and recorder, it was limited in sensitivity, accuracy, and dimension. The more current techniques use a single-axis inertial reference such as a vertical gyro or accelerometer in conjunction with other sensors to provide vehicle roll information and/or to compensate for vehicle body motion in the measured roadway profile. This technique, though more sensitive and accurate than the contact technique, suffers from lack of dimension (i.e., measuring only roll, to the exclusion of pitch and yaw).

The NASA Technology: An Inertial Platform

Source: Marshall Space Flight Center, Huntsville, Alabama

During NASA's space program, considerable R&D effort on gyro stabilized guidance and control systems was reported. Included in this work was the basis for an improved method of acquiring railway and highway profile measurements in three dimensions and selecting data of engineering interest. The method is based on the use of an inertial platform consisting of a double gimbal-mounted plate that is rotationally stabilized by means of three independent gyroscopes whose axes are aligned along an orthogonal coordinate system. Three integrating accelerometers, also mounted on the stabilized plate and orthogonally oriented, provide inertial reference signals to a data acquisition system. This platform, properly isolated from the test vehicle's suspension system, is the basis of NASA's road/rail profiling technique.

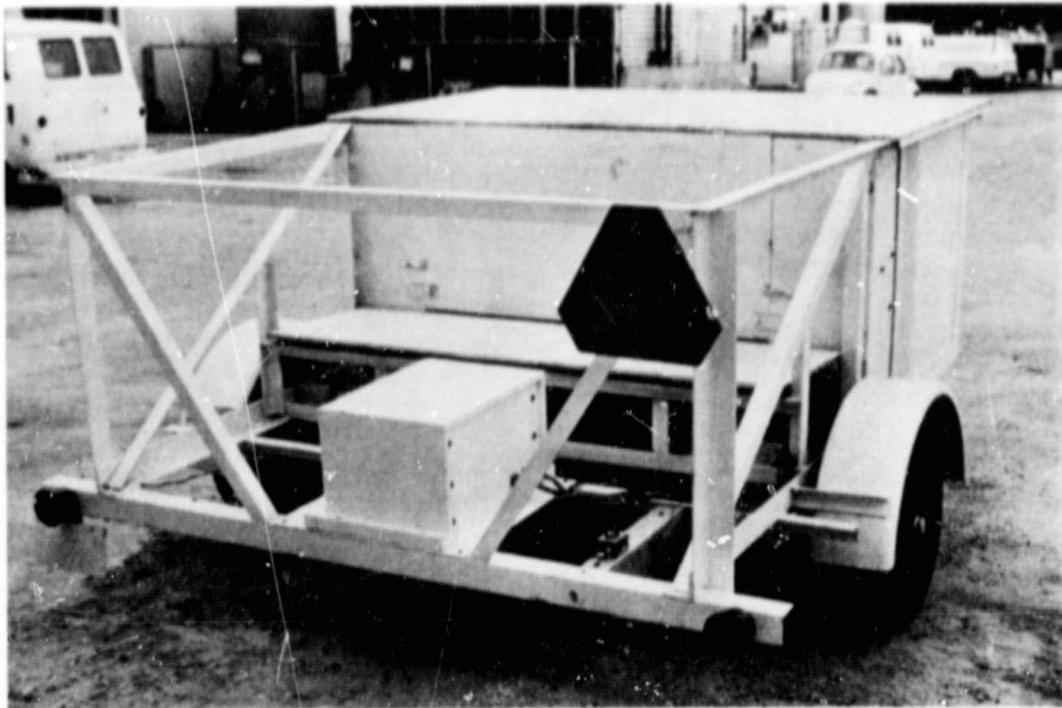
A prototype of the NASA platform (Figure 3), assembled at MSFC, is being included in the ongoing FHWA's hydroplaning test program at Southwest Research Institute, San Antonio, Texas. The platform is being used to locate areas where water is apt to collect, especially depressed spots and flat spots having insufficient runoff. NASA loaned the platform to the FHWA for the preliminary effort so as to determine the feasibility of using a stabilized platform for road profile data collection. Feasibility was indicated, and a copy of the NASA platform was built into the FHWA system. This application represents the first non-NASA user review of the instrumentation.

The completed FHWA hydroplaning test system was demonstrated in June 1978 at Southwest Research Institute. The system gave accurate, repeatable readings, thus validating the concept for highway use. The final report on the system and test results will be issued by the Southwest Research Institute in 1979. The SRI Team will assist in the promulgation of the report to ensure that all those potentially interested in using this technology will have the opportunity to do so.

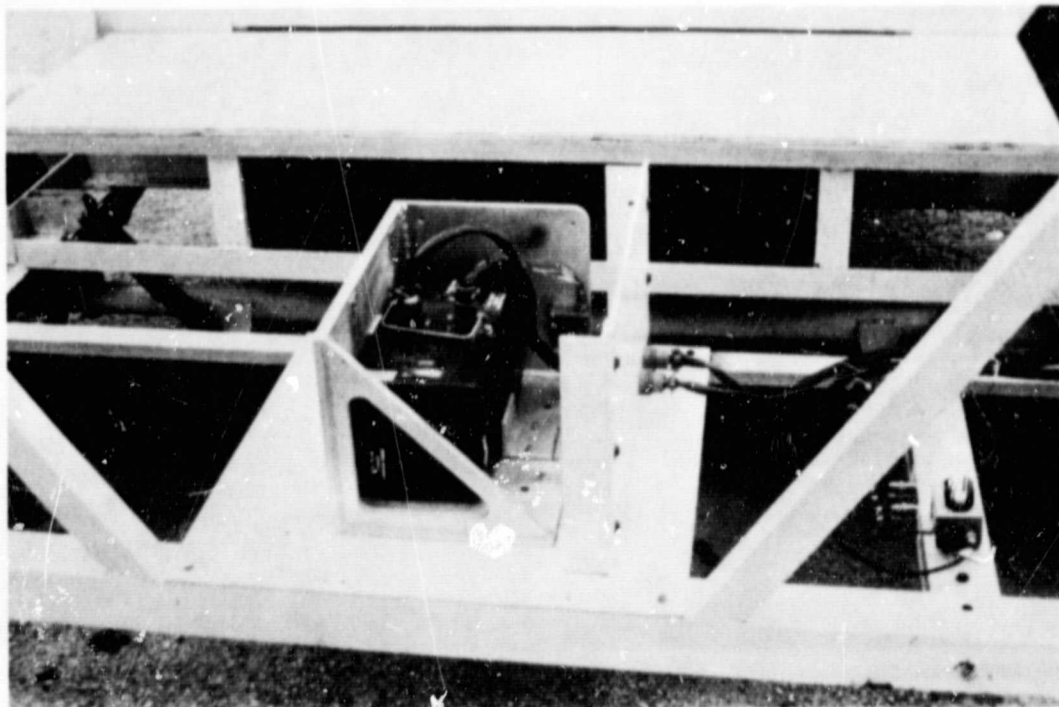
Differentiation of Shale Types

Background

Because the soil in many southeastern states contains large quantities of shale, this material is used extensively for highway construction. These shales come in many varieties, with shear-strength characteristics ranging from rock-like to clay-like. Shale encompasses a broad range of sedimentary rocks varying in color, hardness, structure, and chemical composition. Unfortunately, no dependable method has been found for differentiating these shale types to ensure appropriate applications as subgrade or fill materials or as drainage blankets. As the result, the highways have suffered embankment slides, slope shifts, pavement heaving, and pavement collapse (see Figures 4 and 5). Some of the worst problems have been caused by those shales containing large percentages of montmorillonite.



(a) THE MSFC EXPERIMENTAL SKID TRAILER



(b) THE MSFC INERTIAL PLATFORM
INSTALLED IN THE SKID TRAILER

FIGURE 3

NASA'S HIGHWAY SKID TESTER

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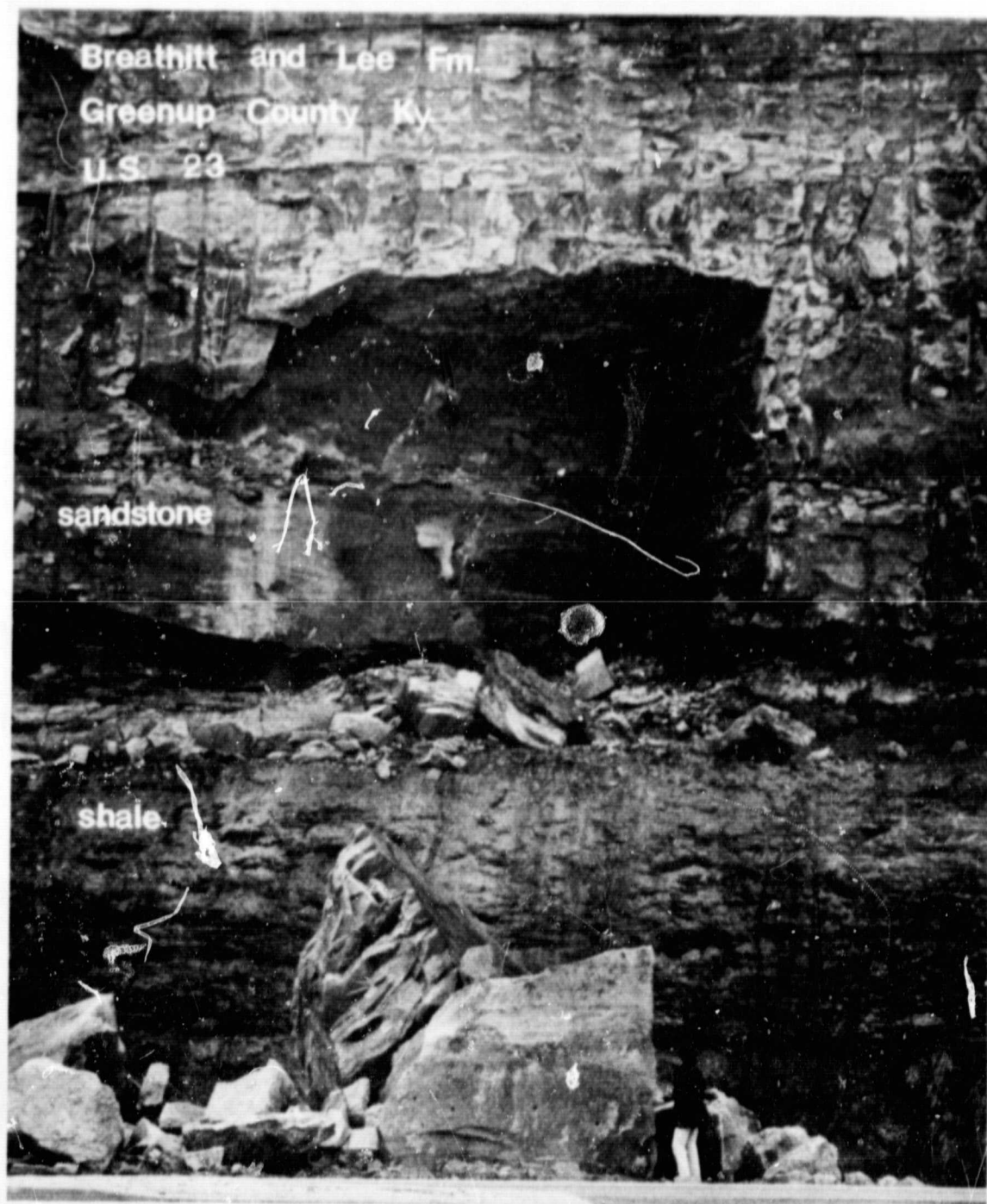


FIGURE 4 EMBANKMENT FAILURE — U.S. 23, GREENUP COUNTY, KENTUCKY

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FIGURE 5 EMBANKMENT FAILURE — I-64, BATH COUNTY, KENTUCKY

These highly overconsolidated clays, which are very expansive, are the primary cause of pavement heaving.

Current tests to identify shale types include: color classification (darker shales usually contain organic materials that are harder), hydrochloric acid/shale reaction as an indicator of calcium carbonate content (cementing agent), general hardness (Shore scleroscope, Schmidt hammer, drop hammer), slaking tests that measure the disintegration of shales during repeated wetting and drying, petrographic analysis, specific gravity, mineralogy, shrinkage (direction of shrinkage indicates the orientation, and thus, the identification, of the clay minerals), and compression. All of these tests are inadequate in some way, usually because of a lack of accuracy and/or of instrument portability. Almost all require that hundreds of samples be extracted and carefully marked for laboratory analysis, a time-consuming process.

Recent Activity

The SRI Team is currently seeking technology that would enable the construction of a portable instrument capable of identifying different organic shales. The use of such a device, on-site, would substantially expedite the construction and ensure the safety of roads and highways in the southeastern United States.

III RAILROAD AND RAPID-TRANSIT PROBLEMS

RECENTLY IDENTIFIED RAILROAD PROBLEMS

The railroad industry today still is afflicted by the same basic industry problems that it has faced over the past decade. The most worrisome problems are the continuing declines in the rail's share of the market (i.e., the absence of "traditional" rail markets) and the continuing apparent public apathy or disinterest in the fate of the railroads. In an endeavor to counteract these problems, increasing amounts of federal funds are being made available to the railroads. Attempts at a revitalization of this mode of transportation are under way, albeit too slowly to suit many in the industry.

New technologies and new systems are now needed to reduce costs and increase profitability. Old and new problems must be addressed to ensure rail safety and reliability. Some of these problems the SRI Team gathered include:

- Technology is needed to control weeds over a 20-foot wide right-of-way without using material that could poison the water table or surrounding land. Brush and forest fires can be started when train brake sparks ignite weeds near the track.
- A better low-cost (less than \$1) fastener of rail to wood cross-ties is needed. The long-used spike for fastening rail to cross-ties is easily loosened by the passage of trains, creating the need for much track maintenance to avoid unsafe track conditions.
- Technology is needed to prevent coal from freezing to itself and the inside of the cars, or to quickly loosen coal without car damage. In the winter, coal-carrying hopper cars are frequently damaged by methods used to loosen frozen coal just before unloading. Some shippers use giant shakers or torches and in some cases dynamite to loosen the frozen coal.
- Bullet-proof, rock-proof windows with good abrasion resistance for locomotives, cabooses, and highliner passenger cars are needed. The railroad unions are upset because several train workers have been shot in recent months.
- An abrasion-resistant coating or new material is needed. The slope sheets of hopper cars wear faster than the rest of the car body because of abrasion from the lading (e.g., coal), especially during unloading. Austenitic stainless steel is being considered, but it is too expensive. One manufacturer has a coating on its hopper car slope sheets.
- Technology is needed to absorb the damaging shock and vibration before it reaches the lading. Shock and vibration are major causes of damage to lading.

- A longer-lasting air filter is needed. Fiberglass and paper filters are used now. Locomotive air filters must be changed every 90 days and can be a costly maintenance item.
- A sound-absorbing material or barrier that will last in the harsh vibration environment is needed. Car retarders in classification yards are very noisy and bring complaints from nearby neighborhoods.
- Lighter weight box car doors are needed. Box car doors are heavy and hard to move and are frequently damaged when forklifts are used to move them.
- A protective coating is needed because coal-carrying hopper car bodies wear quickly. Sulfur in the coal combines with water to create sulfuric acid that chemically attacks the steel car body interior, and the abrasive action of the coal mechanically wears the steel.
- A longer-lasting antirust coating is needed. Wayside signal equipment cases and houses must be repainted every 2 to 3 years.

Problems similar to those listed above, as well as more technical ones, can be anticipated to surface at an increasingly greater rate. This increase will lead to greater Team involvement/interaction with the industry than has been possible over recent years; accordingly, it could be expected to yield significantly more transfer opportunities as well. Specific problems of interest that the SRI Team addressed in 1978 are discussed in the following pages.

GRADE-CROSSING TRAIN DETECTION SYSTEM

The collision of motor vehicles and trains at highway/railroad grade crossings results in more fatalities per accident than any other type of railway accident. Approximately 1,000 people are killed and 6,000 people are injured in 12,000 grade-crossing accidents each year. In addition, grade-crossing accidents represent a major cost to railroads because of resulting lawsuits, equipment damage, and delay of operations.

Currently, only about one-fifth of the 220,000 grade crossings of public roads have automatic motorist-warning signals. Although an active warning system consists of four subsystems (train detection, control, motorist warnings, and interconnections), the train detection subsystem has the greatest potential for improvement through the application of new technology.

Current train detection equipment consists of a signal source electrically connected across the rails at a distance from the crossing and a relay signal detector wired across the rails at the crossing. Consequently, when a train is between the signal source and the detector, the signal is short-circuited, the detector receives no signal (which is the operational definition of train detection), and the motorist-warning equipment is activated. The signal source must be connected at a sufficient distance from the crossing to allow a one-half minute advance warning for the highest-speed trains using the track (i.e., maximum train speed of 60 mph).

Approximately 50% of all grade-crossing accident fatalities occur at crossings with activated motorist-warning systems. The typical results of such an accident are shown in Figure 6. Although some motorists do not see the signals, many more probably disregard them, thinking they have time to cross the tracks before the train arrives. This is particularly true at crossings where advanced warning times vary considerably. A train detection system that will allow a uniform warning time therefore should increase the motorists' belief in the signals and result in dramatic safety benefits.

Current grade-crossing warning systems have track-coupled train detection devices that are installed and maintained by the railroads. This is the only highway traffic control system that is not the complete responsibility of highway officials. A train detection device separate from the railroad track and equipment would allow grade-crossing, motorist-warning equipment to come under total highway department jurisdiction.

A new system is needed that would provide motorists with a uniform warning time, regardless of train speed, and/or no direct connection with

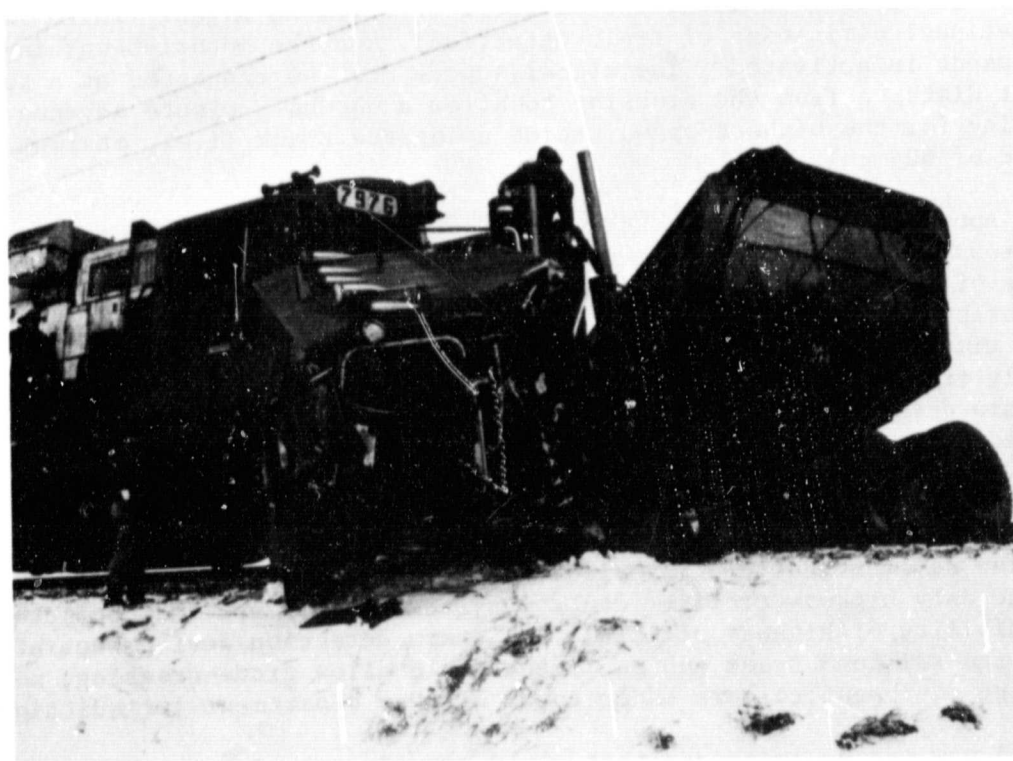


FIGURE 6 AFTER A GRADE-CROSSING COLLISION

the track or train. In addition, an improved system must have fail-safe operation and high reliability (equal to or better than the conventional systems), must be able to handle multiple train crossings, and must have a long lifetime.

Because this problem requires innovative concepts that may relate to a number of technological fields for solutions, the SRI Team issued a problem statement to all NASA centers. In response, the Team received eight concepts from five NASA centers. Unfortunately, on a close examination, none appeared directly applicable or novel. The SRI Team plans to continue its search for new and effective detection systems for the solution of this problem.

FIRE-RESISTANT MATERIALS

Fire safety is a primary concern of the mass transportation industry because all mass-transit vehicles are susceptible to fire damage of some type, and the possibility of a catastrophe is high because of the volume of people transported in such vehicles. Newer vehicles are especially susceptible to fire because increasing quantities of plastics are used in their construction.

For increased passenger safety in case of a fire in a rapid-transit car, especially in the confines of a tunnel, construction materials need to be more fire-resistant than those now used. Improved materials are sought for thermal and acoustic insulation, wall and ceiling panels, floor covering and carpeting, seat cushions, and seat covers.

In addition to fires in cars, the electric cables in subway tunnels also have had fires. With the loss of power, the blinding smoke and toxic gases emitted in a fire in such a confined area can be a greater threat to passengers than the fire itself.

This problem was initially related to the SRI Team by DOT's Transportation Systems Center and the Transit Development Corporation.* In addition, the UMTA and most transit authorities want economical fire-resistant materials for use in their vehicles. In addition to use on rapid-transit cars, the increased use of fire-resistant materials on other passenger-carrying vehicles such as buses, ships, trains, and recreation vehicles would increase safety in travel. For example, government regulations are becoming more stringent regarding fire safety of recreation vehicles, and the U.S. Navy is searching for an electrical cable insulation that will not propagate fire through bulkheads from one ship compartment to another.

As a result of the SRI Team's dissemination of a problem statement describing this need, the SRI Team learned of some highly interesting results of the development of new fire-resistant polymeric materials at the JPL. JPL scientists are making polymeric materials fire resistant by the addition of substantial quantities (of the order of 50% or more) of fillers and additives such as carbonates, hydrates, oxalates, oxides, and nitrogen compounds. When materials made in this way are exposed to flame or high temperature, the filler components generate large amounts of nontoxic gases (such as water and carbon dioxide) to dilute the flammable and/or toxic combustion products so as to inhibit flame-spread and

* Now merged with the American Public Transit Association.

flashover. They will also promote the formation of char or solid residue, giving enhanced thermal protection. In addition, the materials cost little more than polymers currently used in transit vehicles.

Filled polymers have been developed in the past, but they generally have poor physical properties. JPL's unique experience with highly filled polymers for solid-rocket propellants, however, has allowed the preparation of systems with high filler content and yet tailored physical properties. Because results are suitable for application, JPL scientists are working on the adaptation of the materials from the JPL process to specific transit industry components. JPL concludes that of the materials tested, $\text{Mg}(\text{OH})_2$ -filled EPDM rubber has the best overall qualities for a wire insulation. This EPDM rubber was filled to 67% by weight with $\text{Mg}(\text{OH})_2$ and tested for flammability, smoke generation, electrical properties and mechanical strength properties. The material was also extruded in ribbon form and over 20 gauge, 19 strand tinned copper wire as well.

The transit industry continues to be interested in the JPL filled-rubber work because the smokeless cable problem is still active. UMTA, TSC, APTA, and wire and cable supplier company representatives have all expressed interest in using the JPL technology. Boston Insulated Wire and Cable Company representatives visited JPL on September 19, 1978. JPL reports that Boston Insulated Wire and Cable has manufactured insulation very similar to the JPL material, but finds that the JPL material has a desirable property (which was not specified for proprietary reasons) that is better. JPL currently is attempting to establish a secrecy agreement with the company on proprietary matters to enable a more open technical information exchange. Boston Insulated Wire and Cable Company may want JPL's assistance in transferring the technology to a manufacturable and marketable product.

As this technology has successfully reached the transfer stage, the SRI Team plans to minimize its efforts (other than liaison as needed) in this problem area. A number of new problems in Rapid Transit will be initiated in 1979.

A SYSTEMS ASSURANCE PROGRAM FOR THE RAPID-TRANSIT INDUSTRY

The need for urban public transportation in the United States is growing. To meet this need, significant construction and expansion of mass-transit systems are planned and under way.

An increased use of advanced technology, such as automatic train control subsystems, is occurring in the new and expanding fixed guideway rapid-transit systems. The addition of new technology to an already complex transit system can lead to more frequent failures, increased maintenance requirements, and less system availability. To overcome these problems, the elements of systems assurance (e.g., quality assurance, reliability, maintainability, system safety and security, and system life-cycle cost) must be designed and integrated into the overall transit system. To achieve this, improved engineering systems assurance technology and management methodologies for the transit industry are needed. Specifically, system design, test, evaluation, and management methodologies and experience are needed for the complicated process of new system planning, specification, source selection, contract management, systems integration, first-article testing, and system tests.

Most of today's systems assurance technology was originated and developed by the aerospace and defense industry. NASA's expertise in the application and integration of systems assurance led to the successful completion of many large, complex projects such as the Apollo Program. Therefore, the SRI Team initiated an effort designed for the application of NASA's systems assurance and management technology to the rapid-transit industry.

After a thorough investigation of user agency transfer options, the SRI Team directed its transfer efforts toward new transit properties because this approach offered the transit industry a more direct use of the NASA techniques. In meetings arranged by the SRI Team in October and December 1975, the NASA techniques were introduced to the Metropolitan Dade County Office of Transportation Coordination Administration in Miami, Florida, by a Kennedy Space Center (KSC) manager/engineer and a staff member of his support contractor, Boeing Aerospace Company. Subsequent correspondence among staff from KSC, Dade County, and SRI resulted in a draft statement of work for a technology transfer project to adapt NASA's Program Control System for use by Dade County.

These SRI Team efforts resulted in an Urban Mass Transportation Administration (UMTA) and NASA agreement to fund a technology utilization project. Dade County requested the assistance of NASA engineers and managers to adapt and use the system during the design, construction, and

operation of a rail rapid-transit system in a project currently under way for the county.

As originally conceived by KSC and Dade County, the KSC/Boeing Aerospace Company team would work with Dade County by having one man on-site in Miami to adapt the NASA program control system. After a lengthy review by KSC top management, it was decided in September 1976 that the NASA technology requested by Dade County would instead require the transfer of high-level NASA management techniques and systems. The original KSC/Boeing team was not considered appropriate for this function, and a search was launched to find an available qualified NASA manager.

After consideration of a number of candidates, in September 1977 NASA TU selected Mr. Preston Beck, formerly of MSFC and KSC to be the NASA representative on the Metropolitan Dade County Rapid-Transit Project. Mr. Beck began his 1-year effort in October 1977.

In October 1977, Dade County's consulting engineers had already developed risk management, configuration management, and quality assurance systems for the Stage I project. Consequently, NASA HQ TU and Dade County agreed to modify Mr. Beck's role to one of the advisor and conduit to NASA technology for solution of problems that arise with the use of the Dade County program control system. In addition, Mr. Beck is providing Dade County with needed NASA technology for solution of a number of hardware problems (e.g., corrosion control, metals, electrical and electronic systems). (See Figure 7.) The SRI Team now acts in a supporting mode and continues to apply information and specifications, as requested.



NOTE: Mr. Preston E. Beck (left) and Mr. E. Randolph Preston (right), Director, Transit System Development,
Date County, Florida

FIGURE 7 MESSRS. BECK AND PRESTON DISCUSSING METRO SYSTEM NEEDS

IV OTHER TRANSPORTATION-RELATED PROBLEMS

AN IMPROVED TRUCK MUFFLER DESIGN

Through the Noise Control Act of 1972, Congress established a national policy to promote a noise-free environment for all Americans. Since that time, the EPA has determined that medium- and heavy-duty trucks are the major contributing noise source on our local, state, and national highways. In an attempt to eliminate this source of noise pollution, this agency established Federal Regulation Part 205. This standard, which appears in The Federal Register (Vol. 41, No. 72, Title 40), specifies maximum allowable A-weighted sound pressure levels, measured at a distance of 50 feet from the longitudinal center line path of a vehicle traveling at 35 mph.

The standard and effective dates are:

<u>Maximum Sound Level</u> <u>(dBA)</u>	<u>Effective Date</u>
83	January 1, 1978
80	January 1, 1982
(reserved)*	June 1, 1985

One way to meet these new regulations is to improve the muffler systems of medium- and heavy-duty trucks. A new truck noise suppression device should be more efficient than the present ones, compact (no larger than conventional systems), and have a price similar to that of mufflers now on the market.

Having recognized noise suppression as a significant national problem, the SRI Team had previously identified the noise suppressor described in NASA Tech Brief 74-10261. The noise suppressor consists of multiple bands of acoustically absorbent liners on the inside wall of a duct that forms an acoustic trap that uses the reflective elements on the ends to direct sound into the sound-dissipating element in the center. It consists of three cylindrically stacked segments, each of a different porosity and radial thickness out from the inside diameter. It is capable of doubling the noise attenuation of a conventional muffler at peak noise level. Developed at LRC, the patented noise suppressor was designed for use in turbofan aircraft engine inlet and exhaust ducts.

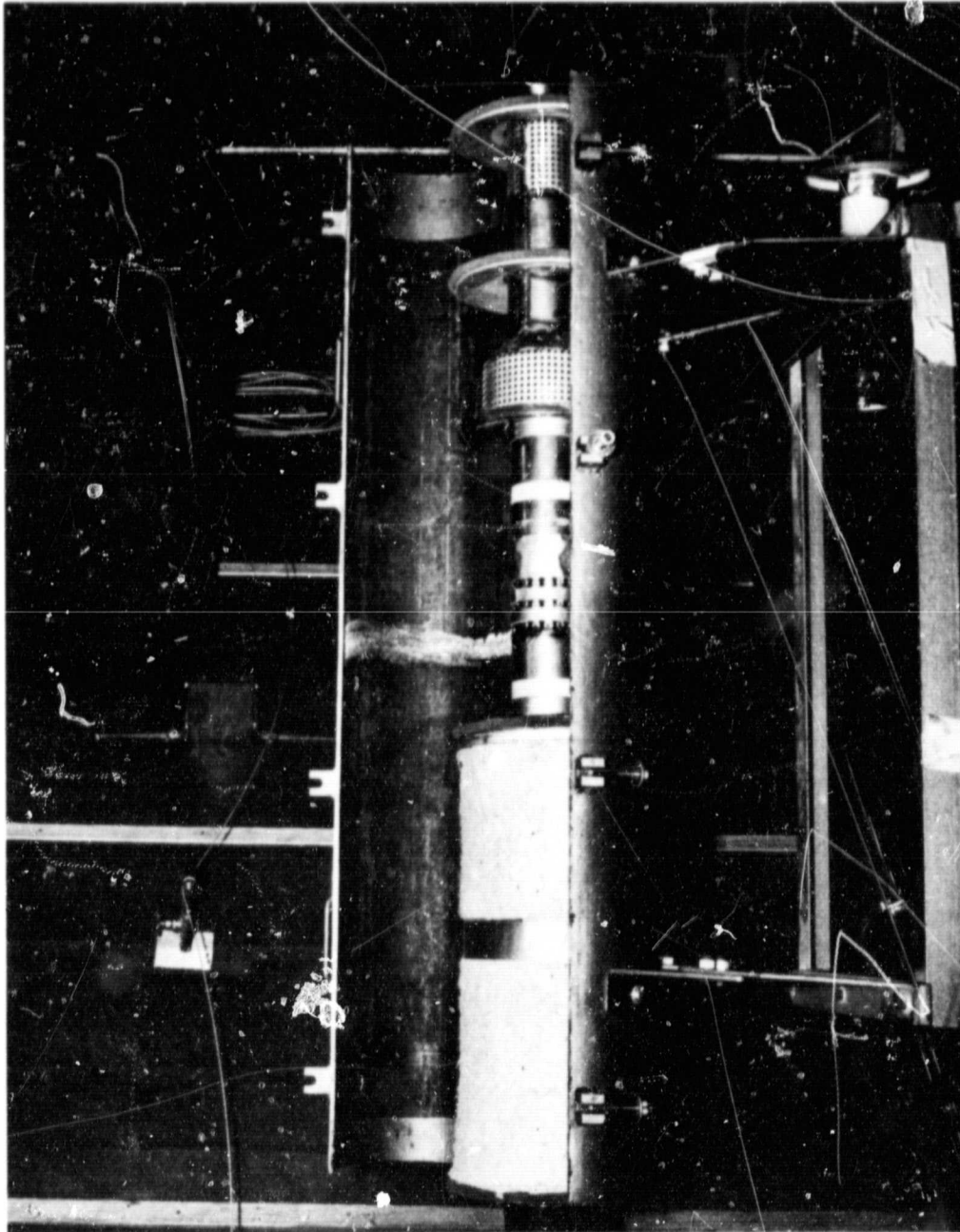
* This standard is expected to be in the 76- to 77-dBA range.

Manufacturing interest was developed through contact with Donaldson Company, a heavy-duty truck muffler manufacturer. At Donaldson Company's request, the LRC noise suppressor tech brief and patent disclosure were supplied by the SRI Team; NASA TND-8348, "Optimal One-Section and Two-Section Circular Sound-Absorbing Duct Liners for Plane-Wave and Monopole Sources Without Flow," and NASA TMX-73951, "Prediction of the Acoustic Impedance of Ducts" were supplied by LRC. After review and discussion with Dr. William Zorumski, the NASA innovator, Donaldson Company has decided that it would like to develop and evaluate a truck muffler using the LRC segmented liner technology. As a result of a visit to Donaldson's corporate office and R&D center in Minneapolis, Minnesota, the SRI Team concluded that the Donaldson Company has the capability and desire to develop, test, manufacture, and market a segmented liner truck muffler based on the NASA technology.

In August 1977, Donaldson Company began the evaluation project of the segmented liner for use as a heavy-duty truck exhaust muffler. A 1-day meeting was held at LRC to begin the transfer of LRC segmented liner technology for truck muffler development. The theory behind the LRC noise suppressor design was discussed, as well as the associated LRC computer program to suggest design specifications for use in building an experimental segmented liner truck muffler. Since August 1977, excellent communications have been established between Donaldson and LRC. The SRI Team now serves mainly as an observer to ensure a smooth transfer and proper recognition for the NASA technology.

Donaldson Company has recently completed wall-impedance tests of candidate muffler construction materials to obtain the input data that are needed by LRC to recommend design parameters for a preliminary truck muffler prototype. A truck muffler test fixture was designed and the experimental segmented liner installed (see Figure 8). Testing continues, and SRI continues in its liaison role, offering technical or other assistance as required. The Team expects that this LRC technology will reach the full commercialization stage in 1979.

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SOURCE: The Donaldson Company

FIGURE 8 TRUCK MUFFLER TEST FIXTURE CONTAINING LRC SEGMENTED LINER

V LAW ENFORCEMENT/PUBLIC SAFETY PROBLEMS

BACKGROUND

In Spring 1978, the SRI Team initiated an ongoing program in the area of law enforcement and public safety. To date the Team has worked closely with various law enforcement departments and divisions in the State of California. These include the Department of Corrections, Office of Emergency Services, California Highway Patrol, and various local police departments, fire departments, and other organizations. The law enforcement/public safety area is the latest problem area to be investigated by the SRI Team, and it has considerable potential for the application of NASA technology.

In the area of law enforcement the Team has reestablished a local Technology Transfer Team. This team consists of an SRI Team representative and police officers already involved in planning and research. The members are drawn from a diversity of departments including intermediate and large organizations and the California Highway Patrol. Additionally, the Team has remained active in the Association of Police Planning and Research Officers. This statewide organization provides a good forum for the Team's problem identification and information dissemination activities.

On September 26, 1978, Dr. Bob Lee and Mr. Charles C. Kubokawa from ARC, Mr. Ray Gilbert from NASA Headquarters, and Dr. Lo Christy from the SRI Team met with officials from the California State Department of Corrections. The Director of the State Department of Corrections, his principal buyer, the Warden of San Quentin, and others all expressed interest in working with NASA to identify new and existing technologies to make the prison system safer and more humane. The SRI Team will work closely with the statewide prison system personnel in identifying and developing practical solutions to high-priority problems. The commitment of the administration to improving and creating a model prison project will assist in the rapid diffusion of technologies. The State of California requires several new prisons to be built during the next decade. This growth mode provides an opportunity to assist in the design of new prisons by supplying and developing advanced technology.

PROBLEM AREAS

Law Enforcement

Public safety problem areas include the following:

- Economical replacement for safety flares: This is an abnormally large expense, particularly for the California Highway Patrol.
- Fingerprint detection: Existing methods are inefficient and are particularly messy.
- In-flight radar systems for car speed control: The existing method of following a car and timing its speed is inefficient. The desired system could be used on both planes and helicopters. The California Highway Patrol finds the existing speed limit difficult to enforce. An in-flight radar system could deter speeding.
- Data compression technology to allow high-speed transmissions of reports from the patrol car to headquarters.
- Stress-related information and management techniques: All public safety personnel work in a stress-inducing environment. Early retirement, strokes, and hypertension are costly side effects of stress. The Department of Corrections and all fire and police organizations are interested in knowing more about the effects of stress and ways of managing it. This information would be helpful in their hiring and promotion procedures.
- Improved uniform materials for fire fighters and police: Fire fighters are particularly worried about synthetic uniforms which could melt when close to fires.
- Gas sensing device: Requirements include a device that differentiates between different gases and identifies them and/or identifies the material that is burning by analyzing the gas detected. Several fire departments have requested such a device.

Emergency Services, State of California

Office of Emergency Services problem areas include the following:

- Improved communications system during natural and man-made disasters: Communications are necessary during times of disaster. Even with the microwave backup network, existing systems may be inadequate during emergencies. Search and rescue missions in wilderness areas find current communications inappropriate because of "dead" spots. Satellite communications systems are of interest to OES. California will be experimenting with an ATS-3

satellite and desires more information about its capabilities. The Office is exploring the applicability of NASA's collapsible tower antenna "Astromast."

- Food and medicine storage: During emergency situations, particularly war-related civil defense, additional food and medicine are required. Present methods for storage need to be updated.
- Flood and landslide detection: Each year floods kill more U.S. citizens than any other natural disaster. In Southern California and elsewhere, flash floods are not detected soon enough. A satellite early-warning system offering information about ground moisture content, types of soil, and changing weather patterns would aid in flash flood control. Other ground-level detection methods are being investigated.
- Improved hazardous material-handling equipment and clothing: Public employees who clean up after hazardous material accidents are at times not properly equipped to prevent injury to themselves. Some materials can penetrate the protective clothing now issued.
- Human detection equipment: The capability to detect a trapped human under the rubble of a building or avalanche has been requested by the Office of Emergency Service for use by fire and rescue units.

Department of Corrections (Prisons), State of California

Department of Corrections problem areas include the following:

- Prison guard distress signal: Increased incidence of prisoner attacks has led administrators and guards to request a distress signaling device. This device must be able to indicate the guard's position within the labyrinthian prison layout. Transmission problems exist because of the required use of iron and concrete in prison construction.
- Improved perimeter security and detection systems: The SRI Team is exploring the applicability of NASA's "Silent Alarm" and its seismic detection capabilities to prison conditions.
- Improved fire-resistant materials for prisoner bedding: Mattresses and blankets pose a real threat to prisoner safety. The bedding material ignites periodically, either accidentally or deliberately. Many prisoners die in confined quarters each year (Figure 9). Even when currently available fire-retardant materials are used, toxic gases are emitted.
- Transportation and storage of prepared foods: An increasing number of prisons are building centralized kitchen facilities. Prepared foods need to be transported and stored, causing long periods of delay. The Team is exploring the applicability of the "integral heating system," a NASA spinoff.



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FIGURE 9 A TYPICAL CELL AFTER A FIRE

- **Drug sensors for ingested items and external body searches:** Illegal drugs are prevalent in prison populations. Existing methods of drug detection allow a virtual stream of drugs to enter prisons. State and city police also request such devices. During many search operations, a drug abuser hoping to avoid detection will swallow a balloon full of heroin. If the balloon breaks, the person may die of an overdose.
- **Improved prisoner restraint systems:** Existing handcuffs and their steel casing may harm the wrists of a struggling prisoner. Even while moving a prisoner in and out of cars, excessive bruises may result because the handcuffed arms are secured behind the person.
- **New materials for utensils and other implements for prison life:** A major worry of prison officials is items that can be fashioned into weapons. Existing metal knives, forks, and spoons are unsatisfactory. Commercially available plastic utensils are also inappropriate. Many other areas of prison life could be improved by new materials development.
- **Better emergency lighting and battery backup:** The SRI Team is investigating whether the electronic lighting system, "Multi-Mode," is satisfactory for prison use. Other lighting needs of correction institutions are being explored.
- **Sensors to detect bar sawing:** Correction officers must routinely examine the bars of each individual cell to determine their integrity. Prisons will saw bars during minimal patrol hours and will use soap and other compounds to deaden the sound. These sawing techniques are slow, but effective (Figure 10). A novel sensor system to detect the noise or vibration of sawing would considerably reduce the need for this maintenance.

Primary activity in 1978 was devoted to gathering and validating the problems listed above. Team activity in 1979 will be directed toward their solution.



FIGURE 10 SAWED BARS

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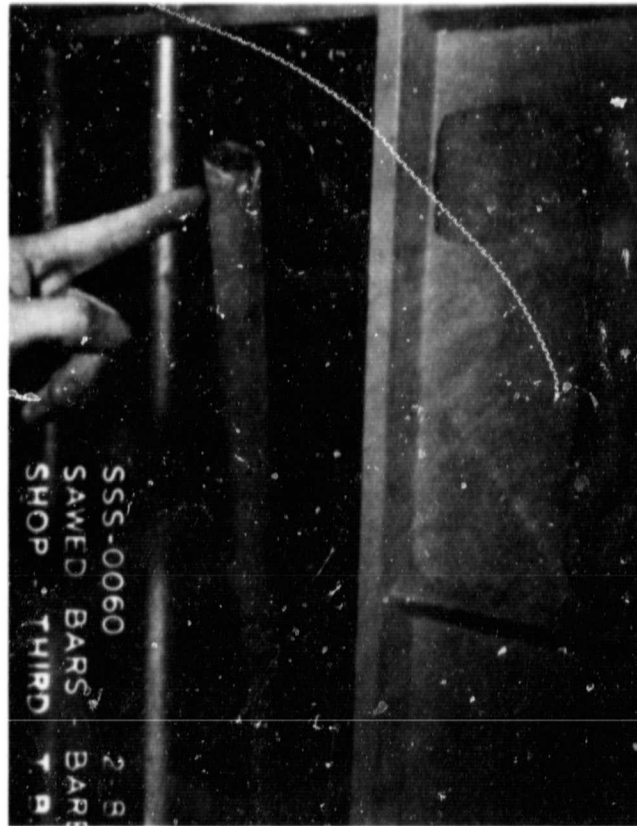


FIGURE 10 SAWED BARS (Concluded)

APPENDICES

Appendix A

CODES AND ABEREVIATIONS

Appendix A
CODES AND ABBREVIATIONS

NASA Centers

NASA HQ	■ NASA Headquarters
ARC	■ Ames Research Center
DFRC	■ Dryden Flight Research Center
GSFC	■ Goddard Space Flight Center
JSC	■ Johnson Space Center
KSC	■ John F. Kennedy Space Center
LRC	■ Langley Research Center
LeRC	■ Lewis Research Center
MSFC	■ Marshall Space Flight Center
NSTL	■ National Space Technology Laboratories
WFC	■ Wallops Flight Center
JPL	■ Jet Propulsion Laboratory

Department of Transportation (DOT) Codes

FCP	■ Federally Coordinated Program
FRA	■ Federal Railroad Administration
FHWA	■ Federal Highway Administration
MTB	■ Materials Transportation Bureau
NHTSA	■ National Highway Traffic Safety Administration
OST	■ Office of the Secretary of Transportation
TSC	■ Transportation Systems Center
UMTA	■ Urban Mass Transportation Administration
USCG	■ U.S. Coast Guard

Department of Commerce (DOC) Codes

MarAd	■ Maritime Administration
NOAA	■ National Oceanic and Atmospheric Administration
OMBE	■ Office of Minority Business Enterprises

Department of Justice (DOJ) Codes

FBI	■ Federal Bureau of Investigation
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State Government Codes

Caltrans	= California Department of Transportation
CHP	= California Highway Patrol

Industry Trade Associations

AAR	= Association of American Railroads
APTA	= American Public Transit Association
ATA	= American Trucking Association
AWO	= American Waterways Operators, Inc.
HDTMA	= Heavy Duty Truck Manufacturers Association
RPI	= Railway Progress Institute
RVIA	= Recreation Vehicle Industry Association
TBEA	= Truck Body and Equipment Association
TTMA	= Truck-Trailer Manufacturing Association
TDC	= Transit Development Corporation

Miscellaneous Abbreviations

APPRO	= Association of Police Planning and Research Officers
NCHRP	= National Cooperative Highway Research Program
STIF	= Scientific and Technical Information Facility
TAT	= Technology Applications Team
TRB	= Transportation Research Board
TU	= Technology Utilization
TUO	= Technology Utilization Officer

Appendix B

EXCERPTS FROM A SPECIAL STUDY:
SUGGESTED APPROACH FOR A REHABILITATION INFORMATION SERVICE
IN THE STATE OF CALIFORNIA

- Executive Summary
- Rehabilitation Technology Applications Unit

EXECUTIVE SUMMARY

The Technology Utilization Office at ARC has shown a continuing interest in the concept of a rehabilitation engineering information system that might be based, in part, on experiences of the NASA Technology Utilization Program. To assist the California Department of Rehabilitation in designing an information system, ARC offered to sponsor a study to determine the size and scope of the rehabilitation engineering community, the current data bases, and the product lines. During the Spring of 1978, the SRI Team was introduced to representatives of the California State Department of Rehabilitation by Mr. Herbert Holley of the ARC TU Office, and it was agreed that the SRI Team should conduct the predesign study.

The study is complete, and excerpts of the final report, "Suggested Approach for Rehabilitation Engineering Information Service in the State of California" are included in this section and in Appendix C. The whole report will be available, upon request, to all interested parties.

Introduction and Background

An ever-expanding body of rehabilitation engineering technology is developing in this country, but it rarely reaches the people for whom it is intended. The increasing concern of state and federal departments of rehabilitation for this technology lag was the stimulus for a series of problem-solving workshops held in California during 1977.

These workshops were organized by the California Department of Rehabilitation. Participants included representatives of Rehabilitation Engineering Centers; Veterans' Administration; hospitals that diagnose handicapped patient needs and prescribe devices; rehabilitation engineers who design the devices; engineering schools that train rehabilitation engineers; industry; social and vocational assistance agencies; funding agencies; legislators; and consumers.

A total of ten workshops were held throughout the state. One of the ten was a general workshop and nine workshops covered special areas such as prosthetics, mobility, sensory deficits, and environmental barriers. During the workshops, participants identified over 100 deterrents to effective rehabilitation engineering technology service. By grouping these identified deterrents, workshop organizers from the California Department of Rehabilitation (Mr. Edward V. Roberts, Director) condensed the list to nine as follows:

- Lack of effective information dissemination.
- Many agencies with many functions (sometimes overlapping) and the resulting confusion.
- Insufficient funding for R&D and evaluation programs.
- Limited number of device suppliers.
- No product evaluations by consumers.
- Unrealistic payment schedules of funding agencies.

- Low-volume market.
- Make-shift curriculum and poor professional image of rehabilitation engineer.
- Inadequate transportation for consumers to access delivery services.

Because communication and lack of information dissemination were expressed most often, and because these barriers are basic to the others, a well-designed rehabilitation engineering information system was selected as the most important ingredient of an effective rehabilitation engineering delivery service. As the Long Beach Workshop report put it:

A good information system would go a long ways toward solving many of the rest of the problems in the rehabilitation engineering field, and in addition, many of the other problems will not lend themselves to solution until the information system is complete.

As a result of the workshops, the recommendation emerged that the California Department of Rehabilitation take the lead in the development of a coordinated delivery system that would eventually serve the entire state and be a model for similar systems across the nation.

NASA Participation

Because of the success of the National Aeronautics and Space Administration (NASA) in setting up its million document scientific and technical information system, and because of the volume of advanced NASA technology in materials, bioengineering design, and medical developments, the Technology Utilization Office at NASA's Ames Research Center, Moffett Field, California, has shown a continuing interest in the rehabilitation engineering information system concept. To assist the California Department of Rehabilitation in designing an information system, NASA-Ames offered to sponsor a study to determine the size and scope of the rehabilitation engineering community, the current data bases, and the product lines. The gathering of this type of information is an essential element of NASA's technology utilization program, and the NASA-sponsored technology utilization program, and the NASA-sponsored technology applications teams conduct such surveys as part of the technology transfer process.

During the spring of 1978, the NASA-sponsored Technology Applications Team at SRI International was introduced to representatives of the California State Department of Rehabilitation by Mr. Herbert Holley of the NASA-Ames Technology Utilization Office. It was agreed at that meeting that the SRI Team should conduct the predesign study. The Team would gather the requisite information, submit a report outlining its findings, and suggest the future work necessary for the implementation of an effective rehabilitation engineering information exchange system in California.

Objectives

This initial study has as its objectives:

- Identification of the types and scope of information available in the open literature relating to handicapped/disabled problems.
- Identification of the size and scope of the industry providing goods and services to the handicapped/disabled.
- Identification of those involved with the handicapped community in California, including counselors, rehabilitation engineers, (bio)medical research centers/teams, state agencies, and others.
- The initial definition of the necessary size and scope of a California Rehab-engineering Information Service designed for the rehabilitation community.

Method of Approach

To accomplish these objectives, members of SRI's NASA Technology Applications Team undertook the following action:

- A project team was formed. Team members included Dr. Lo Christy, Ms. Ruth Lizak, Ms. Cynthia Vahlkamp, Ms. Gail Kelton-Fogg, and Dr. Tom Anyos. This team met with California Rehabilitation Services Administration (RSA) personnel at the initiation of the project to ensure that the direction and scope of their activities agreed with RSA's thoughts and needs on the subject.
- An open literature search, telephone, and personal contacts identified major sources of:
 - Rehabilitation engineering information.
 - Biomedical engineering.
 - Hardware (products) and product information.
 - Rehabilitation programs.
 - Research results not already covered in rehabilitation and bioengineering above.
- The literature search performed above provided a list of additional sources of information and services. This list supplemented the major source compilation and covered selected smaller producers of rehabilitation-related information.
- Contacts with California RSA identified the approximate number of information users in the last two of the above. Typical of this list are:

- The disabled person and family.
- Rehabilitation engineering service delivery practitioners.
- Rehabilitation counselors, welfare agents, special education programs, etc.
- Manufacturers of equipment/products.
- Educators/legislators.
- Payment sources (MediCal, Medicare, etc.).
- General public.
- The Team identified and interviewed over 200 participants engaged in the major aspects of rehabilitation services delivery. In addition, the Team generated a first cut at what information is most required by the user community.

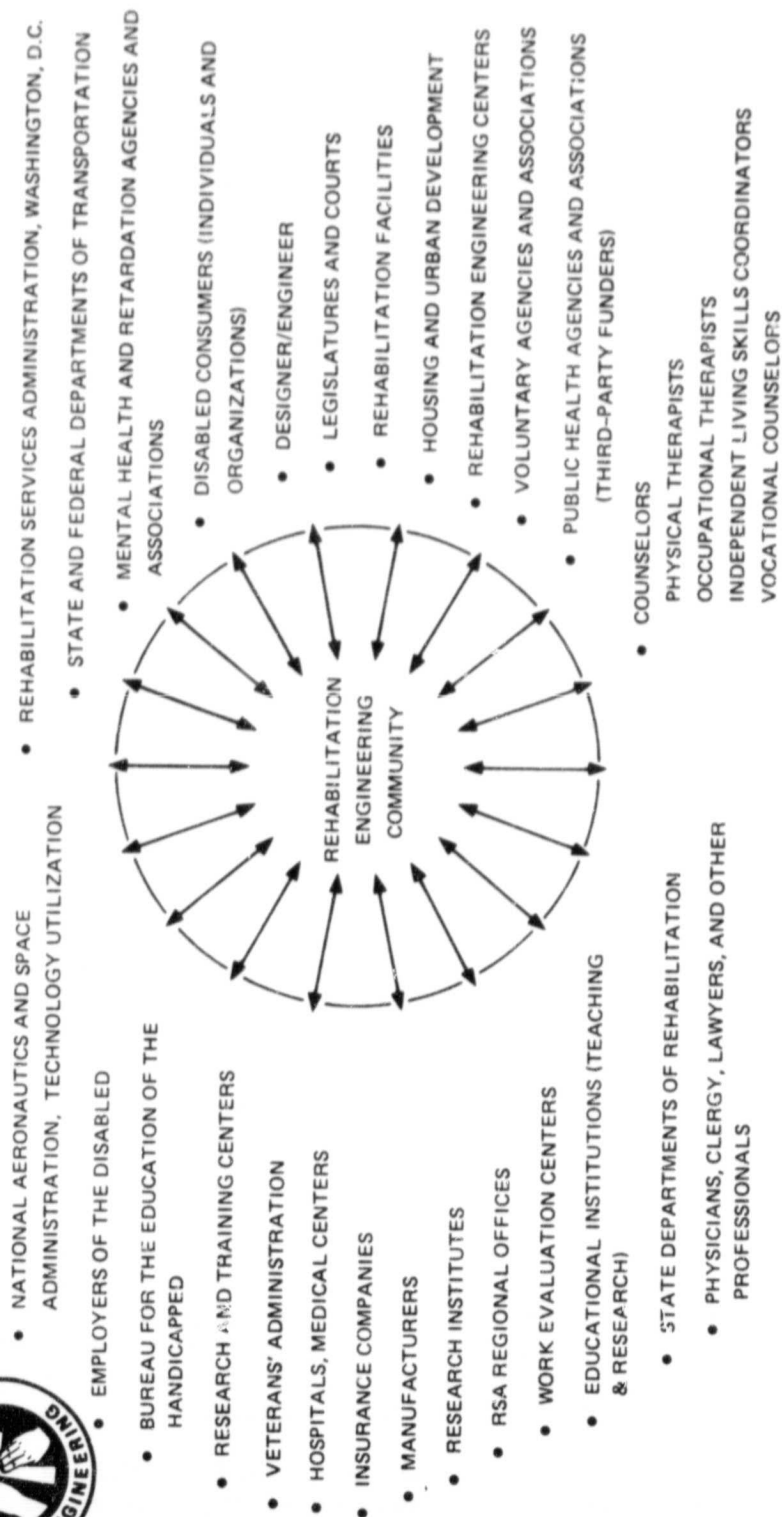
This report outlines the findings of its research effort. The SRI Team also submits its suggestions for the future work necessary for implementation of a full-scale rehabilitation engineering information exchange system in California.

Summary and Suggested Approach

For the majority of America's handicapped people, the application of scientific and technological knowledge and tools has been woefully inadequate. These inadequacies have made it difficult for them to overcome the many problems they confront daily. At all levels, from recipients to researchers, there has been a universal demand for a service delivery network that would aid in the development and transfer of technologies and information from the laboratories and clinics into practice.

Improved information exchange is the key for developing service delivery to the disabled. Indeed, there seems to be a universal agreement within the rehabilitation community that the central problem is lack of access to information. Judicious use of communication and information retrieval and processes offers a significant potential for enhancing the effectiveness and efficiency of the service delivery system. An improved information system will help not only the disabled consumer, but also the whole professional rehabilitation community (see Figure 3).

This study was conducted to develop a suggested approach for establishing an effective rehabilitation engineering information service for the state of California. The study's goal is to improve the delivery of services and assistive devices to the disabled by creating a communications network in conjunction with an improved system of information retrieval and dissemination in the rehabilitation community.



THE PROBLEM: How can these diverse groups integrate into a functional community through better information and communication?

THE GOAL: To improve the delivery of services and assistive devices to the disabled by creating a communication network and an improved system of information retrieval and dissemination in the rehabilitation community.

FIGURE 3 MEMBERS OF THE REHABILITATION ENGINEERING COMMUNITY

To develop the initial model for an information service, the SRI Team first undertook an information needs profile of selected segments in rehabilitation. The segments chosen include a profile of consumers, counselors, rehabilitation engineers, administrators, practitioners (medical doctors and nurses), and manufacturers. Funding, the costs for service and equipment, and the subsequent payment were discussed within each of the affected segments. The information needs profile was developed through extensive interviews in more than 200 organizations that were either organized or affected by the disabled. Additionally, an extensive search of the literature was undertaken to better understand the dynamics of the rehabilitation community. Through this process, the barriers that impede the transfer of research results into patient care were brought into focus. The format and content of the proposed information service emerged as the specific needs of each segment were identified.

These profiles provided the basis for the second major portion of the study. The purpose of this part of the research was to identify existing information models and systems both from within the world of rehabilitation and from other sources. The experience of NASA in information documentation and dissemination proved to be particularly helpful in the consideration of possible models. Thus, by matching a ranked list of informational needs with various models for information processing and communication, the SRI Team was able to provide a suggested approach for setting up a model system for service delivery. This model system, known as the California Rehabilitation Engineering Technology Services (CARE-TECH), would be run by the California Department of Rehabilitation. This proposed project would focus on the issue: "How can the needs of the disabled be served through an improved rehabilitation engineering technology service delivery system?"

The purpose of this study is not to make final recommendations concerning an information service for CARE-TECH. Rather, the results are to provide an orientation and basis for further discussions among NASA, the California State Department of Rehabilitation, and the rehabilitation community.

Suggested Approach

The objective of the proposed California Rehab-engineering Information Service (CRIS) is to support the provision of rehabilitation services to handicapped individuals through the use of technology and information. CRIS consists of three separate organizations that gather and disseminate information. Each suggested organization has its own domain of responsibility and unique interface with the other organizations. (See Figure 4.)

The first organization recommended to be part of CRIS is the Rehab-engineering Information Center. Its responsibility will be to close the technological gap with the direct service arm of the rehabilitation community--e.g., counselors, consumers, and practitioners. Various services

INFORMATION EXCHANGE POSSIBILITIES

INFORMATION EXCHANGE WITH
OBJECTIVE: TO SUPPORT THE PROVISION OF REHABILITATION SERVICES TO HANDICAPPED
TECHNOLOGY AND INFORMATION

Provide access to computerized data banks for literature searches and a catalog of devices

Transfer technology and shorten the time gap between the discovery and effective use of new knowledge in the marketplace

Identify barriers and incentives to the technology transfer process

Disseminate new information related to the rehabilitation engineering field

Evaluate and select needs of the consumer and professionals in rehabilitation community that require new research

Provide consumer feedback and clinical evaluation of selected devices

Develop the necessary community infrastructure for dissemination of evaluative information

Maintain an inventory of devices to be used for training, for evaluation of devices, and consumer education

Serve as a source for documents, blueprints, and audio visual materials

Provide information regarding the safety, effectiveness, and durability of new products and techniques

Serve as a resource of videotapes, photographs, and specifications concerning the recommended application and prescription of devices

Develop studies on the cost-effectiveness of rehabilitation engineering services and devices

Create guidelines governing the purchase of technical equipment

Define an array of technical aids that best serve certain disabilities and functional losses

REHAB-ENGINEERING INFORMATION CENTER

Disseminate available information and technology to the service arm of the rehabilitation community.

Services:

- Equipment design and consultation
- Telephone call-in
- Catalog of devices
- Repair and service directories
- Model aid center
- Mobile training and aid units

DISABLED CONSUMERS*
REHABILITATION
PROFESSIONALS

EVALUATION CENTER AND CLEARINGHOUSE

Assemble testing results and develop criteria for benefit analysis of technical devices and rehabilitation services.

Services:

- Standardization of testing protocol
- Clearinghouse for existing evaluations
- Consumer feedback processing
- Laboratory testing and clinical evaluation of devices
- Consumer newsletter

NOTE: Computerized teleconferencing can assist in developing a national network linking segments in the communication network will support the implementation, operation, and deployment of the Service Delivery Model.

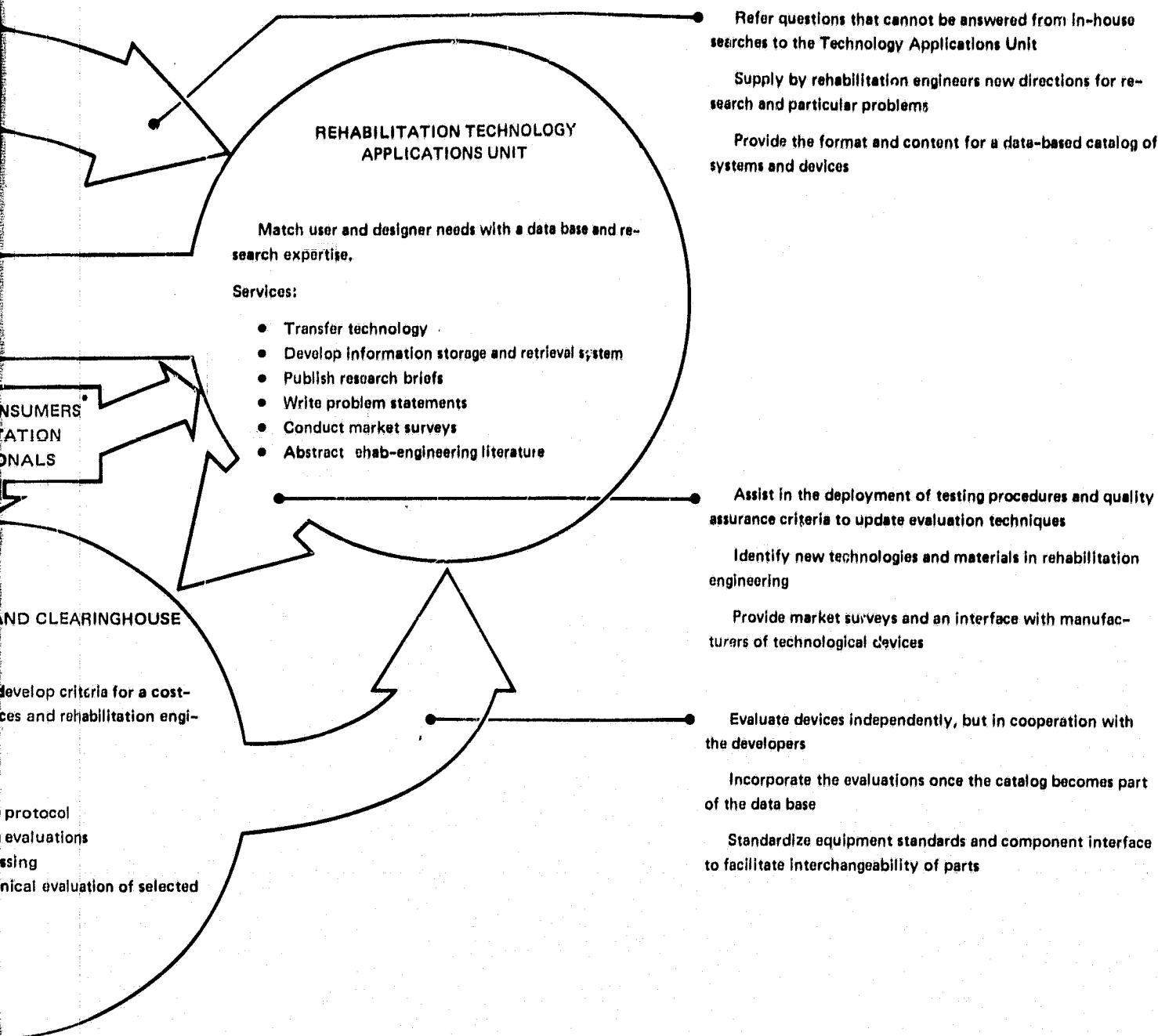
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FIGURE 1 THE THREE AUTONOMOUS ORGANIZATIONS OF THE

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CHANGE WITHIN CRIS
 SERVICES TO HANDICAPPED INDIVIDUALS THROUGH THE USE OF
 INFORMATION

INFORMATION EXCHANGE POSSIBILITIES



network linking segments of the rehabilitation community. Participation
 operation, and deployment of findings of the California Rehab-Engineering

CTIONS OF THE PROPOSED INFORMATION SERVICE

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will be provided to develop a community infrastructure capable of disseminating the latest information and technology concerning rehabilitation engineering. The Center's responsibilities include the preparation of catalogs of assistive devices and systems, and repair and service directories; equipment design and consultation; mobile training units; a telephone call-in service; and the processing of consumer feedback on devices and services.

The second recommendation entails the creation of an independent, nonprofit evaluation center and clearinghouse. This center will assemble testing results and develop criteria for a cost-benefit analysis of technical devices and rehabilitation engineering services. Tasks that it will perform are to act as a clearinghouse for consumer feedback and professional evaluation, test selected equipment, establish standard testing protocol, and publish a consumer newsletter with an in-depth addendum for professionals.

The purpose of the third recommended organization, the Rehab-technology Applications Unit, is to link user and designer needs with a data base and research expertise. This act of linking, better known as technology transfer, is a process by which a technology, usually newly developed, is brought into use. The proposed Rehab-technology Applications Unit is a composite model based on NASA Technology Utilization Program combined with examples drawn from existing rehabilitation programs. NASA's dissemination formats, computer data bank configuration, and technology applications teams were analyzed for their applicability to rehabilitation engineering. Other models from the National Library of Medicine, the NSF project on teleconferencing, and the Texas IMPART program, were also investigated for possible application.

Transfers of most newly developed technologies can usually be expected to occur slowly and sporadically in the absence of some deliberate effort to expedite their implementation. The Rehab-Technology Applications Unit will pursue both passive and active techniques. Passive transfer is simply the dissemination of information related to the technology in question. In active transfer, a transfer agent follows and aids a transfer from its initial needs identification to the use of the technology. The services provided by the Applications Unit include: transferring technology, developing an information storage and retrieval system, publishing research briefs, writing and disseminating problem statements, and performing market surveys.

To effectively deliver rehabilitation engineering services, more is needed than an information system that provides data or facts and documents or listings of documents that contain them. A means for creating a communications network that links parts of the rehabilitation community together to accomplish this common purpose is required to complement the services provided by an information system. Thus, in this study, major information disseminators on rehabilitation have been identified including laboratories, universities, and companies engaged in rehabilitation engineering. Additionally, the size and scope of the

industry providing goods and services to the handicapped are outlined. If these segments are formed into a network, each component would allow others to use its resources and, at the same time, it would gain access to network resources that would otherwise be unavailable.

Computerized teleconferencing can assist in developing a national network linking segments of the rehabilitation community. Participation in the communication network will support the implementation, operation, and development of findings of the California Rehab-engineering Service Delivery Model. Complementing the information system in California with a larger communication network will produce a powerful model for a rehabilitation information service.

The service delivery goals in rehabilitation of equity, effectiveness, and efficiency remain distant. This application of science and technology can "enable" the handicapped by improving their health and providing mobility, communication, and independence--but only if the services and devices are available. Inadequate communication in the rehabilitation community hinders maximum utilization of our national expertise and knowledge. Duplication of effort, inappropriate expenditures of funds, and uninformed decisions are all the logical result of communication problems within the rehabilitation community as a whole and for rehabilitation engineering in particular. An improved information service would assist the rehabilitation professionals and ultimately bring more handicapped individuals into the mainstream of America.

The Rehab-technology Applications Unit is described in Appendix C. This suggested Unit borrows heavily from the NASA experience in storing and processing information. The rest of the study has not been included because of its length. Those parties wishing to procure a complete copy should contact the SRI Technology Applications Team.

REHABILITATION TECHNOLOGY APPLICATIONS UNIT

NASA's Technology Utilization (TU) program could serve as a model for the proposed Rehabilitation Technology Applications Unit. The primary mission of NASA's TU Office is the same as the objective of the suggested unit in the rehabilitation field. "... the widest practicable and appropriate dissemination of information..."

The specific objectives of the NASA program are:

- (1) To increase the return on the national investment in aerospace research and development by encouraging additional uses of the knowledge gained in those programs.
- (2) To shorten the time gap between the discovery of new knowledge and its effective use in the marketplace.
- (3) To aid the movement of new knowledge across industrial, disciplinary, and regional boundaries.
- (4) To contribute to the knowledge of better means of transferring new knowledge from its points of origin to all points of potential use.

The last three objectives could serve as a preamble to the proposed Technology Applications Unit.

The problems currently identified in rehabilitation have been addressed through the NASA program. Learning from NASA's mistakes and experience will help prevent duplication of effort. The retooling of these programs and experiences to fit the needs of rehabilitation will be accomplished through the arduous process of discussion and negotiation.

A major element in the rehabilitation plan of any physically disabled individual is equipment, assistive devices, or hardware. There is a dichotomy in the availability of assistive devices. Technological advances provide the context for potential improvement in the assistive devices needed by the disabled today; however, existing equipment does not embody these advances. The lack of technology transfer mechanisms and information dissemination needlessly hampers the rehabilitation community.

NASA has a major program in information retrieval and dissemination and has developed a number of approaches and solutions that are currently in use. This section outlines the scope of a program by examining several models provided by the NASA TU Program and other examples drawn from organizations committed to information utilization.

Technology Transfer Process

Basically, the technology transfer agent identifies public sector problems by interacting with key decisionmakers who can define these problems. For their solution, the transfer agent contacts scientists and engineers who bring their technology to bear on the problems. To complete the transfer, the transfer agent coordinates any required adaptive engineering and development program.

The various activities of a technology transfer can be outlined into a four-step program, as shown in Figure C-1, with a risk-reducing GO/NO GO decision point between each step. Two levels of activity proceed simultaneously through the transfer process. The first, shown above the dashed line, is the problem-solution level; the second, shown below the dashed line, is the market-product level. Each box represents an activity to perform and each bar represents a decision point.

When the technology can be used directly (such as with a computer program or a welding technique), only the problem-solution level functional activities (i.e., problem survey, technology survey,* adaptive engineering and development, and technology application) are followed. (See Table C-1.) However, if the transferring technology needs to be manufactured in a commercially available form before it can be used (as would be the case with a new material or instrument), market-product level requirements must also be satisfied before proceeding past each risk-reducing decision point. At these points, it must be asked: Is there a real problem (market)? Is there a potential solution (potential product)? Is there a real solution (business opportunity)? The terms in parentheses are the additional market-product level requirement.

In product-oriented transfers, the transfer agent not only is solving a technological problem but also is identifying a market. This type of transfer can be successful only when the business and technical aspects are pursued in parallel so as to reduce concurrently the risks associated with technical, market, and investment development.

It is with these commercial technology transfers that the early and active participation of the private sector is needed for an effective transfer of technology. Without it, the transfer agent's effort becomes relatively passive and little, if any sector interaction is achieved.

Barriers to the transfer of newly developed technologies are similar to those encountered in commercial development efforts: resistance to change, technical adaptation problems during development, the need for prototype qualification, and the accompanying refinements and design changes. Nevertheless, for a technology's utilization, it must be made

* A technology survey outlines the state of the art of the relevant technology by surveying open literature, computer data bases, and individuals expert in the technology.

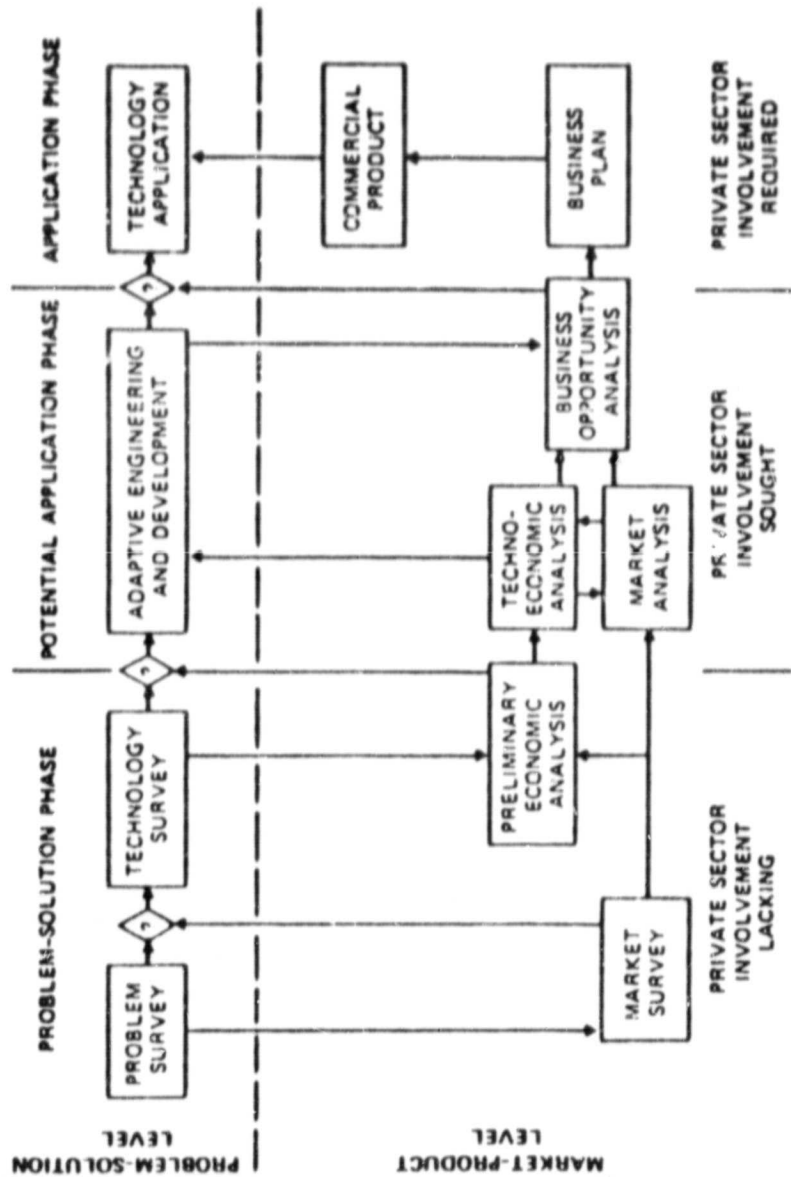


FIGURE C-1 FUNCTIONAL ELEMENTS OF A TECHNOLOGY TRANSFER PROGRAM

Table C-1
ANALYSIS OF A TECHNOLOGY TRANSFER PROGRAM

PROBLEM SURVEY • Problem definition • Benefits from solving problem • Consensus on nature and priority of problem • Constraints on solutions • Previous attempts at solving problem MARKET SURVEY • Commercial product requirement • General market characteristics for this product • Other products on the market • Companies manufacturing these products • Description, specifications, and price of each product • Shortcomings of each product TECHNOLOGY SURVEY • Technology previously investigated • Reasons for unsatisfactory results • Technology relevant to the problem - Review open literature - Search appropriate data banks - Contact experts - Circulate a problem statement • Proposed solution(s) worth pursuing PRELIMINARY ECONOMIC ANALYSIS • Projected production costs • Cost comparison with available products • Ways to reduce costs • Potential savings due to - Extended product life - Lower maintenance costs - Product use • Overriding non-economic benefits	MARKET ANALYSIS • Product use • Product procurement • Appropriate communication and distribution channels • Barriers and hurdles • Size of market segments • Product variation requirements • Appropriate pricing schedule • Expected future changes in the market • Dynamics of the market in response to a new product introduction TECHNO-ECONOMIC ANALYSIS • Performance spectrum for the new product • Performance limitations imposed by new technology • Cost-performance tradeoffs • Important noneconomic considerations • Scope of appropriate adaptive engineering and development program ADAPTIVE ENGINEERING AND DEVELOPMENT (AED) • Accomplish the engineering and development necessary to: - Reduce costs - Simplify operation - Improve performance - Meet all market-imposed requirements - Optimize product design for expected application • Produce, test, and demonstrate prototype(s) as appropriate • Make necessary design changes BUSINESS OPPORTUNITY ANALYSIS • Changes in the techno-economic and market analysis based on the AED program and exogenous considerations • Investment requirement to bring the developed technology to the market • Expected risk/return relationship for the investment • Does the adapted technology constitute a valid business opportunity
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available to the consumer or user, the person with the need. This availability includes all the previously mentioned aspects of the developing and marketing of a commercial product. The technology must first become available; once it is developed, production, marketing, and distribution decisions must be made. Commitment of the product to the proper market need is key to its successful utilization.

According to the usual definition, technology transfer is a search for secondary uses for technology initially developed for a specific mission. In fact, second-generation versions of a given technology often find utilization more rapidly than the basic technology itself. This type of transfer can be carried out by both passive and active techniques.

Passive transfer is merely the dissemination of information related to the technology in question. This dissemination is usually nonspecific, with possibly only minimal direction toward potential interested users of the technology. Additional requests for information are rare, and determination of the ultimate use of the technology is seldom achieved.

In active transfer, the diffusion and implementation of newly developed technologies tend to be more assured by the involvement of a transfer agent. The transfer agent is capable of an overview of specific sector problems and can establish technological needs.

Working within the constraints of the usual definition of technology transfer, the transfer agent does not carry the emphasis on utilization as strongly as he might or should. We believe that without this emphasis, such an agent is not truly effective. Using the definition which states that transfer is achieved only when utilization occurs, one can see the transfer agent can be the developer of the technology, who also brings it to the commercial development and market stage; the user of a technology, who identifies it as fitting his need and then proceeds to develop a product; or the classically defined transfer agent--the third-party broker, who interacts with the source of the technology and its user to ensure its commercialization.

In any event, the transfer agent is the person who brings about the ultimate use of the technology. Someone who merely disseminates information or who merely acts as a broker cannot be considered to be a transfer agent. As will be often stated in this report, utilization of a technology is the determining factor in a transfer. The transfer process then can be best described as an activity in which a transfer agent solves a problem or a need by commercialization of a newly developed or advanced technology.

Information Retrieval and User Service

To promote technology transfer within the nation's industrial complex, NASA operates a network of Industrial Applications Centers (IACs). The responsibility of the IACs is to provide information retrieval

services and technical assistance to industrial clients. The network's principal resource is a vast storehouse of accumulated technical knowledge that is computerized for ready retrieval.

Through the IACs, industry has access to some 10 million documents, the world's largest repository of technical data. About 1.5 million of these documents are NASA reports covering every field of aerospace activity. In addition, the data bank includes the continually updated contents of 15,000 scientific and technical journals, plus thousands of published and unpublished reports compiled by industrial researchers and by government agencies other than NASA. Each month, another 50,000 documents are added to this wealth of technical information.

The IACs seek to broaden and expedite technology transfer by helping industry in finding and applying information pertinent to a company's projects or problems. The philosophy behind the IACs is that it is wasteful to "reinvent the wheel"--that is, there is no need to duplicate research already accomplished and thoroughly documented in the data bank. By taking advantage of IAC services, individual businesses can save time and money, and the nation benefits through increased industrial efficiency and productivity.

The seven IACs are located at university campuses across the country, each serving a geographical concentration of industry. The IACs also have off-site representatives serving industrial clients in many major cities and their surrounding areas. Additionally, six of the NASA field centers have technology coordinators who perform the important function of matching ongoing NASA research and engineering with client interests.

Staffed by scientists, engineers, and computer retrieval specialists experienced in working with companies, the IACs provide three basic types of services to industrial firms contemplating a new research and development program or seeking to solve a problem. They offer "retrospective searches"; they probe the data bank for relevant literature and provide abstracts or full-text reports on subjects applicable to the company's needs. IACs also provide "current awareness" services, tailored periodic reports designed to keep a company's executives or engineers abreast of the latest developments in their fields with a minimal investment of time. Additionally, IAC applications engineers offer highly skilled technical and interpretive assistance in applying the information retrieved from the data bank to a company's best advantage.

Needs of Researchers and Rehabilitation Engineers

Substantial information is being produced with respect to rehabilitation equipment. This information concerns available devices and the data generated from research and development. The information is being produced by NASA, as technology spinoff, colleges and universities in medical and engineering research, medical research centers, rehabilitation engineering centers, private research organizations and handicapped persons.

The engineers and researchers that were interviewed stressed the need for both a data bank with storage and retrieval capabilities and an applications team that could assist in the development of a device from the idea or technique to its ultimate availability in the marketplace. The following section covers the "passive" information transfer means of providing access to existing documented knowledge and suggestions for rehabilitation transfer agents. As was discussed in the information needs profile (Section IV) on rehabilitation engineers, the field is relatively new and could benefit from rudimentary communications links, such as a professional organization and training programs that directly address needs of the rehabilitation engineers. But to be informed about the forefront of technology and the possible secondary application of existing technologies to rehabilitation requires data bases and special publications.

Better information exchange among researchers needs to be approached from several directions, however, and not solely through a data base. One approach, which will be discussed later, is a network developed by computerized conferencing. The capability to contact co-workers across the country could be tied into a data base that is similar in capability to the existing NASA data base.

Proposed Task: Create and Maintain Data Base

The proposed information system would consist of a data base including but not limited to rehabilitation engineering information, biomedical engineering data, hardware and product information, rehabilitation program information, funding for rehabilitation programs, rehabilitation centers, and individuals. Abstracts of information entered in the data base would be subject-indexed and organized for convenient user retrieval. Biomedical engineers, rehabilitation engineers, and researchers would generally access the system directly by use of information searches. Information flowing into the data base would be reviewed, evaluated, and selected for preparation of special publications for dissemination to several user groups such as rehabilitation counselors, welfare agents, manufacturers of equipment and products, and consumers. The rehabilitation information system would provide a tool, not now available, that would increase the cost-effectiveness of providing rehabilitation services in the state of California, and if successful, nationally.

There are some problems in accessing information. First, information system capability is not available to the researchers located across the country, but who have timely in-depth access to present computer-based literature citations. Key-word searchers have sparse information on rehabilitation methodology, state-of-the-art knowledge bases, etc.

Second, access to rehabilitation research and technology developments in other countries is achieved only through international meetings attended by only a few Americans. Written reports on international research and development are available only after long reporting delays in conventional multilanguage journals and periodicals. Considerable duplication of work

done in other countries occurs in the United States. Similarly, foreign countries are unaware of the rehabilitation research being conducted in the United States.

Third, an interchange of information and coordination of research and development related to assistive devices in the workplace, home, and hospital are needed. In this way, the cost of developing assistive devices can be reduced, and more handicapped persons can benefit from using them. Quality of research can be rapidly improved, and unnecessary duplication can be minimized with ready access to better information and linkage with other researchers in the same field of inquiry at the time when dialogue and information are needed. Centralized information services should be established to augment the limited service of some facilities and to enable better communication to the public and professionals regarding the availability of technology and services. Many of the needs of the researcher and technician would be aided by a national computerized data bank on technology.

Fourth, a general-purpose data base and information could assist researchers in this field. The justification for this type of supportive service is found in the need for active communication among researchers because of the breadth and scattering of the research problems in rehabilitation; the widely differing numbers and kinds of researchers and others using research information; the need to have an accessible source of information on the numbers and the typical needs of disabled people who could benefit from the results of proposed research; and the need for a file of existing research activities and the state-of-the-art knowledge to assist researchers and rehabilitation engineers both individually and in groups. The quality of research and design of equipment could be improved and unnecessary duplication could be minimized by a communication system focused on the rehabilitation community. Access to an updated research inventory including the who, what, when, and where, and funding of research together with information on the state of the art in various fields of rehabilitation research are needed.

Fifth, several federal agencies are engaged in the research and development of assistive devices for daily living and the workplace. However, there is little or no coordination of this research effort to reduce overlap, minimize duplication of effort, and obtain maximum effectiveness from the money expended. After assistive devices are developed and proved feasible, there is no adequate follow-through effort to ensure final development and marketing of devices for use by the handicapped. In addition, a wealth of unused research results from the space and defense programs, and these data are potentially adaptable to the needs of disabled persons.

Each of these problems contributes to the unnecessary expenditure of funds and the continuing unavailability of needed assistive devices for handicapped persons.

One approach to setting up a data base for rehabilitation would be to classify the field into specific areas of rehabilitation engineering--that is, upper-limb prosthesis, lower-limb prosthesis, wheelchairs, kitchen aids, visual aids, and so forth. Thus, the system could grow in stages; be accessible during the growing period. The project personnel would accumulate, screen, abstract, and index one segment of the field before proceeding to another.

The suggested approach to system development would be to remain manual until the volume of data and client requests were of a sufficient size to warrant automation. The service delivery process and the information system supporting it should be working well before the whole system is automated into a data base. Even during the manual stage, all efforts should be compatible with the ultimate storage of data in a computer system. The computer data base configuration would be ideal to accommodate interactive inquiry by many of the parties in the rehabilitation community.

The Accent on Information system and the Information System for Adaptive and Rehabilitation Equipment computer-based systems should be explored for possible applicability. Any movement by NASA into this area should be to protect and augment existing systems and not have an adverse effect on programs created by dedicated individuals.

Publications for Accessing the Data Base

The following list summarizes various publications for accessing a data base for a computer network.

STAR

Scientific and Technical Aerospace Reports (STAR) is the principal announcement medium for the worldwide report literature on the science and technology of space and aeronautics. Each issue of this semimonthly publication announces, abstracts, and indexes more than 1,000 items. The informative abstracts are arranged in 34 subject categories, including: aeronautics and space research and development, basic and applied research, aerospace aspects of earth resources, energy development, conservation, oceanography, environmental protection, urban transportation, and other topics of high national priority. As a major component of NASA's information system covering aerospace and supporting disciplines, STAR announces current publication of NASA, NASA contractor and NASA grantee reports, reports issued by other U.S. Government agencies, domestic and foreign institutions, universities and private firms, NASA-owned patents and patent applications, and dissertations and theses.

STAR is issued twice each month, with cumulative index volumes published annually and semiannually. A special section entitled "On-Going Research Projects" is included in each issue. By arrangement

between NASA and the Smithsonian Science Information Exchange (SSIE), a separate section of information on aerospace-related "On-Going Research Projects" is inserted into each issue of STAR. The insert presents titles of active NASA grants and university contracts, summary portions of recently updated NASA Research and Technology Operating Plans (RTOPs), and notices of non-NASA research projects that were funded in the most recent or current fiscal year. The latter are selected by SSIE. The project announcements in the insert are arranged by STAR divisions but are otherwise entirely separate from STAR. They are not indexed nor machine-searchable by NASA.

Figure C-2 displays a sample cover for a proposed abstract journal that would be similar to NASA's STAR.

NASA Thesaurus

In addition to its regular publications containing information scientific report abstracts and references, NASA publishes an annual Thesaurus. The NASA Thesaurus contains the authorized subject terms by which the documents in the NASA scientific and technical information system are indexed and retrieved. Volume 1, "Alphabetical Listing," contains all subject terms currently approved for use. Volume II, "Access Vocabulary," contains postable terms, nonpostable terms, pseudoterms, and other entry terms to provide multiple access to the NASA Thesaurus terminology.

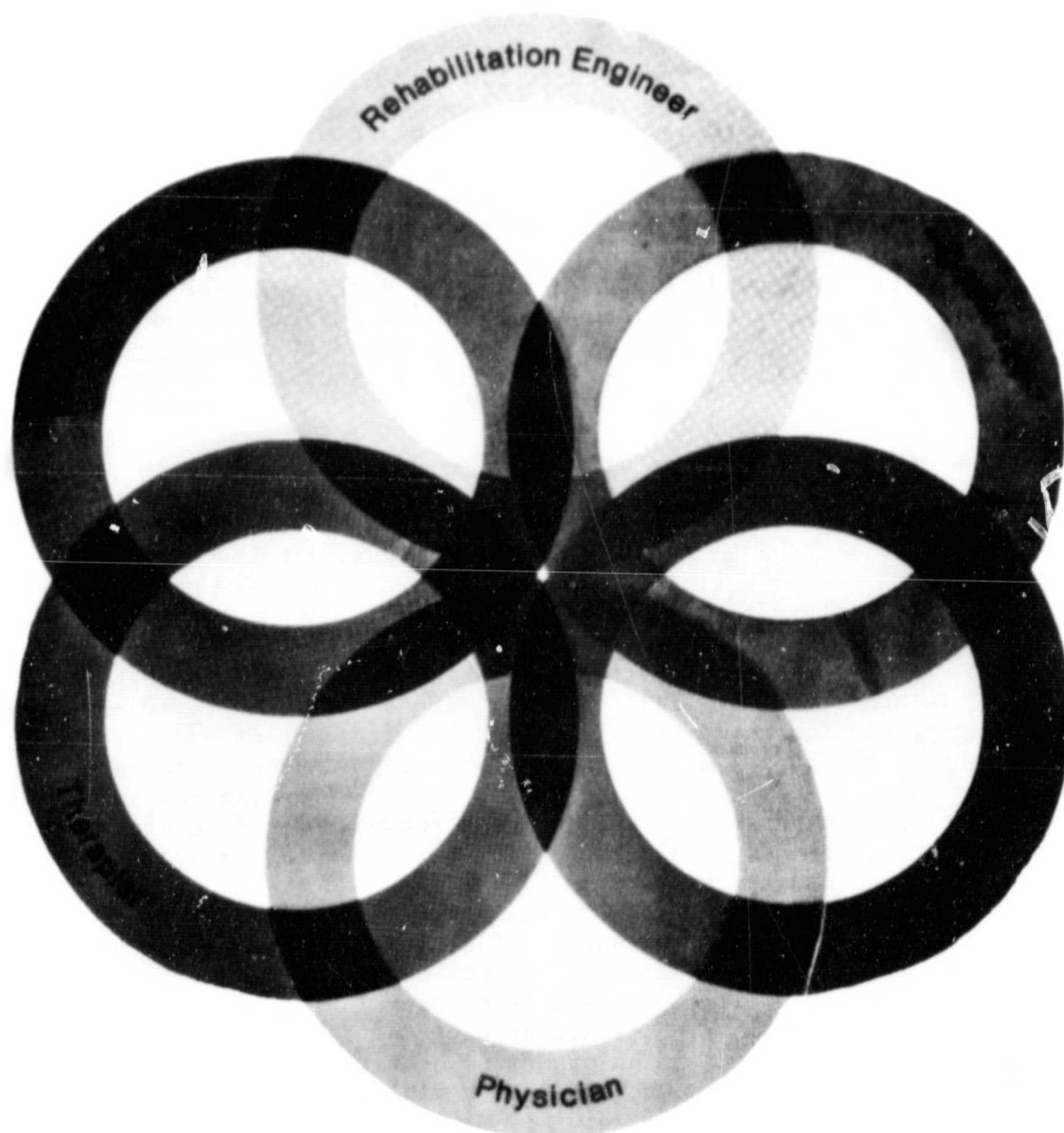
Patent Abstracts

Inventions resulting from NASA research and having important use in government programs or significant commercial potential are usually patented by NASA. These inventions cover practically all fields of technology, including many that have useful and valuable commercial application and are available to business through patent license. This type of service could aid rehabilitation engineers and manufacturers in the latest usable technology. Too often patents transferable to rehabilitation remain unused simply because no one knows about available technologies. To bring these licensable patents to the public's attention, a NASA "Patent Abstract Bibliography" (PAB) is published semiannually. PAB contains comprehensive abstracts and indexes of those NASA inventions originally published in NASA's STAR.

Other Suggestions for the Development of the Rehabilitation Data Base

Apart from existing models provided by the existing NASA TU Program, there are other suggestions that are applicable to the rehabilitation community. The following suggestions could all be used within the data base for increasing information exchange.

REHABSTRACT



A Monthly Abstract Journal
with Index

FIGURE C-2 PROPOSED COVER FOR AN ABSTRACT JOURNAL
SIMILAR TO THE NASA STAR

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Consumers and counselors recommended that a local directory of services and equipment be created. The directory might also include a list of individuals working in areas such as rehabilitation engineering and their speciality. This index should be cross-indexed and made available throughout the community to anyone who needed it. A similar index should be compiled at the state or regional level. The objective of these directories would be to make individuals aware of the existing community infrastructure. These directories would be especially helpful for the newly disabled. The directories could be part of the discharge briefing from the hospital. This information would be an invaluable aid for improving service delivery.

One system that could be either manual or computer-based would be an individualized research service. This service would be based on a consumer information profile that would list the specific interests of an individual. The profile would be used to match articles, books, and conferences with a person's interests, and the information could be automatically sent to the person. The suggestion of computerized conferencing would provide an ideal medium for an individualized research service.

One model for an information transfer system is now being developed by the National Library of Medicine (NLM). Practitioners in the general health field as well as those in rehabilitation have neither the time nor access to sources to meet professional needs. In the attempt to translate new research findings into useful form, the NLM has designed a health care information system.

The library says the system will aim at providing a comprehensive bank of information that will: contain substantive answers to questions posed by practitioners; provide answers that are current and reflect the consensus of a group of experts; be immediately responsive to inquiries--i.e., reliable, ready access; and provide data supporting the answers as well as citations to primary publications for more detailed study, if desired. One area has been selected to serve as a test model for such an information transfer system.

Knowledge pertaining to aspects of a particular sickness important to the practitioner and/or academician has been synthesized into one body or bank of information derived from several reviews or syntheses on the subject previously published by experts. Relevant information has been selected, placed in an organized hierarchical arrangement to permit easy retrieval, and encoded into a minicomputer.

The data base, still in draft form, is arranged by topics (headings). For each heading, there is an accompanying heading--statement that synthesizes the state of knowledge about a subject. Each heading and heading-statement is supported by data elements--paragraphs taken from the previously published source documents. Citations included within the data element paragraphs refer to the primary publications cited by experts in their source document articles to back up their conclusions

or general statements. This draft data base can now be explored via terminals at NLM.

After the prototype computerized information bank is validated and brought up to date, methods of allowing users to access the information will be studied. Access may be direct via a computer terminal or through a trained intermediary using a toll-free, dial-access telephone number; users also may receive computer-generated printed material, either in response to specific queries or as a complete document on a given disease. The information bank also will be made available to professional societies and to other producers of health-related information products and services, ranging from scholarly monographs to multimedia instructional packages.*

Another service that the NLM provides is called MEDLINE. This service is a nationwide, on-line, bibliographic retrieval system provided for the biomedical community. An instantaneous, interactive searching of over 400,000 citations from the world's biomedical serial literature service is provided through a data communications network that allows access through a local data-phone call in major metropolitan areas. Both the NLM's information services as well as the NASA data banks should be further investigated for their applicability to rehabilitation.

Publications for Information Transfer

In addition to the publications for accessing computer-based data, other methods for the transfer of information provide models for consideration in establishing a technology applications unit. Current information systems within NASA provide a starting point for recommendations concerning formats for information dissemination. The following discussion touches on the existing publications that were developed for promoting and stimulating practical applications of government-sponsored aerospace technology. The models can be redirected specifically toward the needs and problems of handicapped individuals. An information dissemination plan should be designed to reach the maximum number of researchers, rehabilitation professionals, and handicapped persons.

In addition to the actions of the transfer agent in bringing together developers and potential users of technology, NASA's TU Program uses a variety of publications designed to further promote the accessibility of aerospace research-generated technology. Taken as a whole, this group of publications represents a comprehensive data base of information on NASA technology. Singularly, the various formats allow for ease of use and interpretation by particular audiences.

*The person to contact for more information is Lionel M. Bernstein, Lister Hill Center, NLM, 860C Rockville Pike, Bethesda, MD 20014.

A relatively simple, but important transfer mechanism is the announcement and widest possible dissemination of new knowledge and technologies. The TU office uses this mechanism by issuing the NASA Tech Brief, a short abstract discussing a newly developed technology. Samples of NASA Tech Briefs are displayed in Figures C-3a and C-3b and a sample of a proposed rehabilitation publication cover is provided in Figure C-4. More detailed information relevant to the Tech Brief is available in the form of a NASA Technical Support Package, a report discussing the new technology in greater detail and often containing test data, drawings, and specifications. To supplement these reports, special publications (SPs) are offered periodically on topics such as "Implantable Biotelemetry Systems," "Human Factors Engineering," and "Technology and the Neurologically Handicapped."

Tech Briefs--NASA requires written reports of technical information representing invention, improvement, or innovations made during contracted research and development projects. Such information is announced in the quarterly publication, NASA Tech Briefs. Each issue contains information on more than 100 innovations distilled to straightforward, single-page technical descriptions, often with illustrations. The briefs emphasize information likely to be transferable across industrial, regional, or disciplinary lines and are issued to encourage commercial application. A special feature of Tech Briefs is a section on "New Product Ideas," innovations stemming from NASA research that appear to have particular promise for commercial application. One of the most requested items in the information needs survey of the rehabilitation community was to be informed concerning new products and ideas that would lead to future devices. If a Rehab Brief were formed within an applications unit, it should include a new products section.

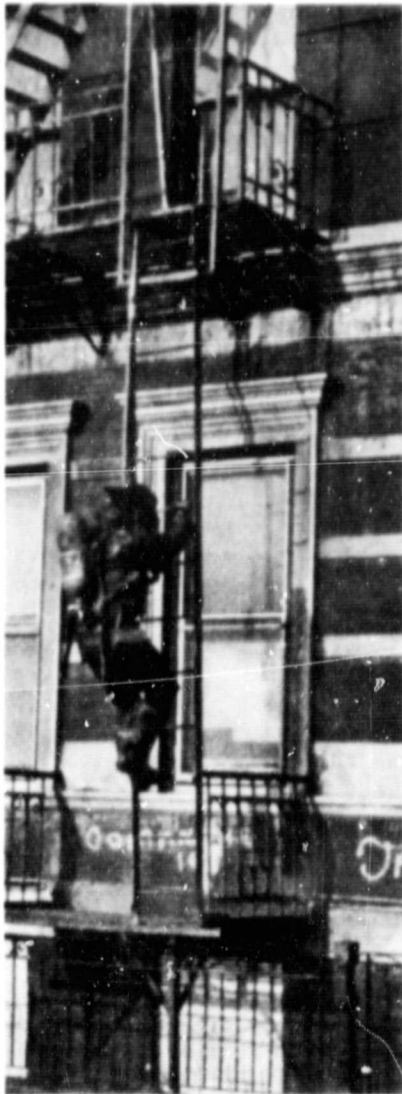
Each issue contains a comprehensive index, and a cumulative index is published annually. Subscription to Tech Briefs is free to engineers in U.S. industry, business executives, state and local government officials, and other potential users of aerospace technology, such as rehabilitation engineers.

Tech Briefs in the form of a Rehab Tech Brief* would benefit many segments of the rehabilitation community by increasing the amount and quality of technical information. Manufacturers, researchers, and rehabilitation engineers would be the primary benefactors of Rehab Tech Briefs. The format of NASA Tech Briefs is shown in Figure C-3.

*It should be noted that "Rehab Briefs" is the name of a publication from the University of Florida. University of Florida produces 12 to 15 briefs per year on timely topics--each 2 to 4 pages long and distributed to 25,000 to 30,000 readers.

NASA Tech Briefs

National
Aeronautics and
Space
Administration

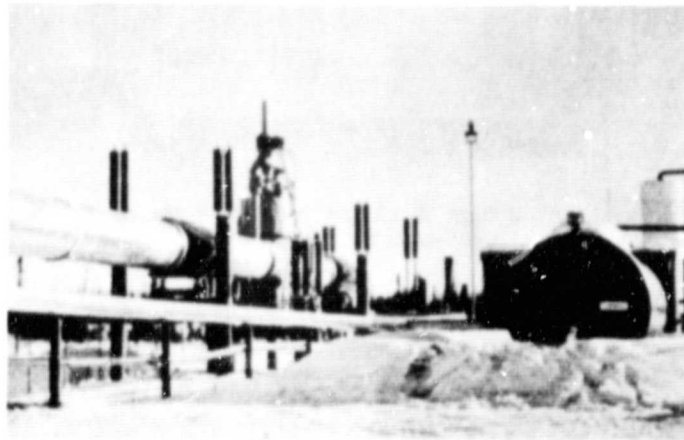


A lightweight fireman's air tank and breathing system are based on technology developed for astronauts' equipment.



Aluminized Mylar, developed originally as reflectors for satellites, is used for jackets, parkas, blankets, sleeping bags, and other consumer products.

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Heat pipes, similar to those used to cool equipment in spacecraft, keep the permafrost frozen around sections of the Alaskan pipeline to prevent frost-heaving damage.

Vol. 1, No. 2

SUMMER 1976

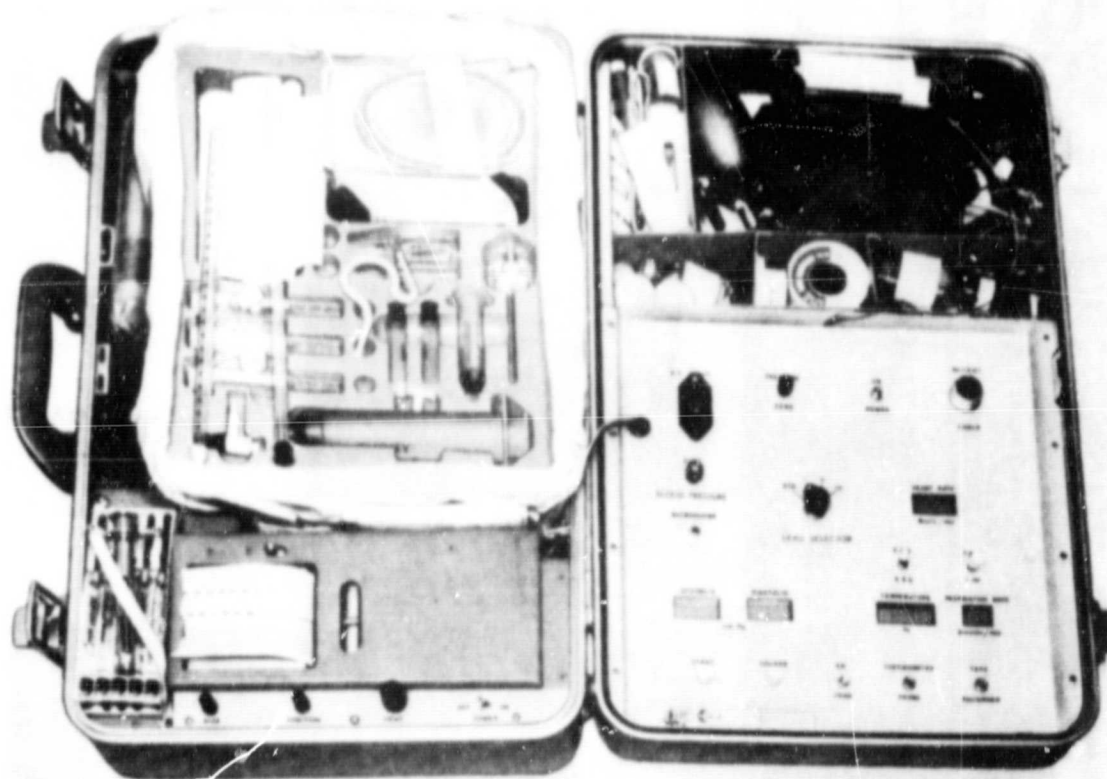
(a) COVER

FIGURE C-3 NASA TECH BRIEFS SAMPLES

Physician's Modern "Black Bag"

A compact medical kit contains most of the instrumentation of a well equipped physician's office.

Lyndon B. Johnson Space Center, Houston, Texas



The **Physician's Modern "Black Bag"** is a lightweight, compact package that contains practically all the instrumentation of a well-equipped medical office.

Physicians on house and emergency calls usually carry a familiar "black bag." The bag contains instruments and drugs necessary for on-site diagnosis and treatment. Heavier, more sophisticated equipment is kept in hospitals and doctors' offices to examine the patients more thoroughly. A physician's capabilities for on-site treatment are greatly extended by a new

"black bag" that contains practically all the instrumentation of a well-equipped medical office. The entire unit which is packed in a suitcase weighs less than 14 kg (30 lb).

The unit includes the electronic equipment, drugs, bandages, and instrumentation necessary for relatively thorough diagnosis and treatment. It is packed into an 18-cm by 56-cm by 36-cm (7-in. by 22-in. by

14-in.) suitcase for hand carrying.

The electronic components include an electrocardiograph (ECG) and electroencephalograph (EEG). Data are recorded either on a built-in strip-chart recorder or on a cassette tape recorder, and a built-in telephone coupler can be used for data transmission over a standard telephone line. A single printed-circuit card is used to

FIGURE C-3a

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control the measurement and display of vital data, such as heart rate, respiration rate, temperature, and blood pressure. The card is also used to precondition ECG and EEG signals for the strip-chart recorder or the telephone.

A small self-contained rechargeable battery pack supplies power for all the electronics. The battery can be used for 12 hours and may be recharged from a standard ac outlet. Battery life is enhanced in this system because the instrument data are displayed with power-saving liquid crystals.

In addition to the electronic equipment, the kit contains nearly 50 other diagnostic instruments and supplies. These include a combination laryngoscope-otoscope-ophthalmoscope, a stethoscope, an emergency supply of drugs, hypodermic syringes, thoracentesis, and spinal-puncture trays. All of this equipment is compactly packaged within the "black bag."

The advantages of the new "black bag" are many: It extends the quality of treatment a physician can administer on emergency and house calls and helps obtain more

complete diagnosis prior to hospital admission. Furthermore the electronic instrumentation is sophisticated enough to be used as part of the standard equipment in the physician's office.

This work was done by C. K. LaPinta and J. L. Day of Johnson Space Center and A. E. Schulze and G. A. Zivley of Telecare, Inc. For further information, Circle 63 on the TSP Request Card. MSC 14936

**Fraction-Storage Unit for
Drug-Identification System**

In a drug-identification system which simultaneously identifies several drugs via separate, parallel gas chromatographs followed by IR analysis, one of the chromatographs may elute at a faster rate than others. A fraction-storage unit which connects to each chromatograph output and buffer stores the samples until the infrared spectrometer is ready to accept them. It controls storage column input and output and backflushes each after use to clean the column.
(See page 208.)

**Precolumn for Extract
Concentration**

An automated drug-identification system requires that test samples be separated into families of organic compounds for subsequent insertion into several parallel gas chromatographs. A sample is first extracted by selective organic solvents. Solvent is then removed from the extract to increase the extract-to-solvent ratio. This step, which increases system sensitivity, is used with each chromatograph.
(See page 207.)

Automated Solvent Concentrator

When used in an automated drug-identification system, the concentrator reduces the solvent-to-specimen ratio by 100:1. It feeds input material to the analysis subsystem where each sample undergoes filtration in an extraction tube. The filter simultaneously removes particulate contaminants and reduces the sample water content. The sample is extracted from the filtered residue by a specific solvent.
(See page 206.)



FIGURE C-3a (Concluded)

next cycle only after it has completed the previous cycle. The water supply pressure and the air pressure have no influence on the mechanical operation, but the time of one complete cycle is a function of the water pressure.

All materials in contact with the water are stainless and compatible with water containing iodine as a biocide. All seals in contact with the cooler are food grade. No maintenance is required during the life of the unit.

This work was done by Thomas A. Cook and Hans Scheibe of McDonnell Douglas Corp. for Marshall Space Flight Center. For further information, including design details, Circle 76 on the TSP Request Card. MFS-21163

Omnidirectional Wheel

Wheel with rotating rim elements maximizes the directional driving capability of a vehicle.

Marshall Space Flight Center, Alabama

A specially built wheel provides mobility in any direction for a ground vehicle, without requiring any change of orientation relative to the vehicle. Such wheels will enable a car to get in and out of tight parking spaces, a crane to maneuver directly sideward, or a Moon rover to travel easily over difficult terrain.

Figure 1(a) illustrates the principle of the omnidirectional wheel: It travels forward or backward by turning on its axle, just like any other wheel, and it travels sideward (i.e., in the direction of its axle) by the rotation of a roller-like rim element about an axis in the plane of the wheel.

The rim elements (or rim wheels — sort of wheels on a wheel) are rigid bodies shaped so that their outer contours form parts of the circle defining the wheel diameter. Figure 1(b) shows how they are mounted on rim axles at the outer ends of the spokes of the wheel. Power to drive the rim elements is applied via the rim axles by electric gearmotors or by hydraulic or pneumatic devices.

Simultaneous rotations of the wheel and of the rim segments allow a ground vehicle to move in any direction from a given spot, as depicted in Figure 2. Varying one of the two rotational speeds steers the vehicle along a curved path.

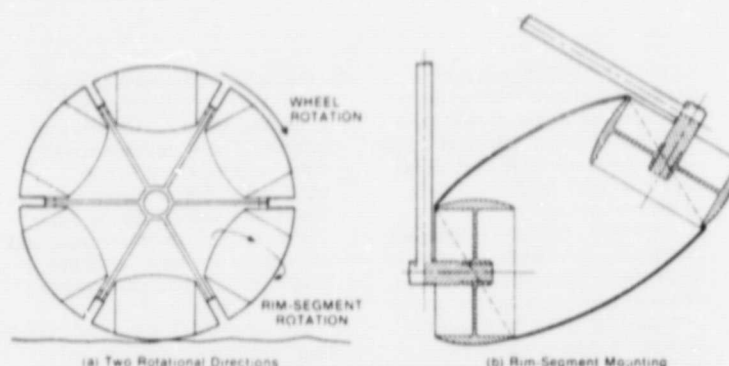


Figure 1. Omnidirectional wheel Rolls in Two Orthogonal Directions at once, as roller-like rim segment turns about axle in plane of wheel while entire wheel revolves on its hub. The two rotations are shown in (a); mounting of the rim segments is shown in (b).

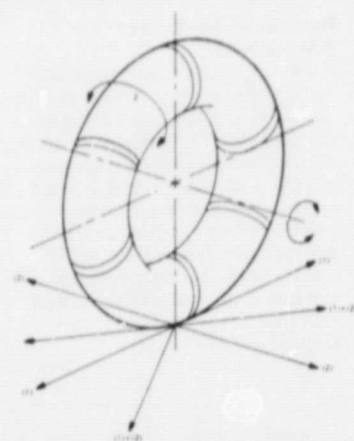


Figure 2. The wheel is Steered Without Orientation Change by varying one of the two rotation rates. A vehicle equipped with such wheels can move in any direction from a fixed spot.

This work was done by J. F. Blumrich of Marshall Space Flight Center. For further information including the details of construction and powering of the rim segments, Circle 77 on the TSP Request Card.

This invention has been patented by NASA [U. S. Patent No. 3,789,947]. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center [see page A8]. Refer to MFS-21309.

FIGURE C-3b

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REHAB BRIEFS



FIGURE C-4 PROPOSED COVER OF A "TECH BRIEF" FOR REHABILITATION

Spinoff--The NASA Spinoff publications may best be described as annual reports, printed in glossy magazine style format and well illustrated with photographs. Directed to the interested lay reader, Spinoff highlights NASA's year with informative feature articles about ongoing space exploration, research programs, and successful application of NASA technology to areas of public interest such as medicine, land use, aviation, weather monitoring, energy-efficient housing systems, vehicle safety, and food technology.

A similar Spinoff for rehabilitation could be a report to the nation about the progress in devices and systems benefiting the handicapped. Many members of the community request a new products and idea listing. This type of magazine can instill hope in the disabled and provide confidence in the service network that serves them. Most consumers would find a newsletter format, including a listing of the latest advances in the field, to be useful.

Special Publications--In addition to these regular publications, NASA issues a variety of specialized material, such as reports, technical handbooks, and data calculations, to acquaint the nonaerospace user with NASA advances in various states of the art. Examples include: "Implantable Biotelemetry Systems," "Optical Devices: Lasers," and "Human Factors Engineering." Special publications many times arise after NASA sponsors a conference dealing with selected areas that are in need of improved communication. An example of such a publication is Neurophysiology and the Handicapped that reports the proceedings of a conference held in 1974. The special publication of NASA corresponds to the requests for the development of a series of in-depth, state-of-the-art monographs on domestic and international research and development activities that have or could have an impact on disabled individuals.

Problem Statement--One of the tools for matching user needs with the existing expertise is to write up and circulate problem statements on selected topics among the NASA scientists. Personal contact with scientists produces results because ongoing research is many times not documented and would be inaccessible for a time without the contact with the researchers themselves. A sample problem statement is provided in Table C-2. Problem statements similar to these would make rehabilitation researchers aware of certain valid needs of the disabled and aid in the technology transfer process.

Building a National Communications Network

Computerized teleconferencing can assist in developing a national network linking segments of the rehabilitation community. Many of the issues and information sources have a national scope and cannot be isolated within the California model service delivery system. Linking participating organizations within California to other national resources

SAMPLE NASA PROBLEM STATEMENT



PROBLEM STATEMENT

FIRE RESISTANT MATERIALS

A problem in Transportation undertaken by the Technology Applications Team at Stanford Research Institute sponsored by NASA's Technology Utilization Office

November 1974

What Is Needed

Fire resistant, non-metallic materials for use in the interior of rail rapid transit cars for thermal and acoustic insulation, wall and ceiling panels, floor covering and carpeting, seat cushions, and seat covers.

Background

Lives have been lost, and extensive property damage has occurred in subway fires in the past. For passenger safety in case of fire in a rapid transit car, especially in the confines of a tunnel, more fire resistant, low smoke, and low toxic gas-producing construction materials are needed. Improved materials are needed for thermal and acoustic insulation, wall and ceiling panels, floor covering and carpeting, seat cushions, and seat covers. In addition to fire resistance the exposed materials must be washable using commercial cleaning agents. Graffiti and vandal resistance are also desirable but not required properties.

Materials currently used and their fire resistance characteristics are listed on the attachment. As the materials specified by different transit authorities vary, the list includes three different car types (distinguished as A, B, and C).

Constraints and Specifications

All combustible materials with the exception of seat cover fabric shall be required to pass or equal to ASTM Specification E-162 (latest revision), Radiant Panel Test with a flame propagation index (I_g) not exceeding 25, with the additional provision that flaming of any drippings shall not be allowed. Furthermore, foam samples must be supported by wire screening to prevent them from falling from the sample holder during the test.

Table C-2 (Continued)

The seat cover fabric must self-extinguish when tested vertically in accordance with FAA Regulation 25.853, Appendix F (b), with the following changes: the average burn length may not exceed 6 inches, and the average flame time after removal of the flame source may not exceed 5 seconds. Flaming of any drippings shall not be allowed. Furthermore, the samples of material shall, after 15 minutes immersion in water and thorough drying, still conform to this test.

The combustible materials must be tested for smoke emission in accordance with the National Bureau of Standards Technical Note 708, "Interlaboratory Evaluation of Smoke Density Chamber," December 1971, Appendix II, "Test Method for Measuring the Smoke Generation Characteristics of Solid Material," dated September 1971. The specific optical density, D_s , determined in accordance with the test may not exceed 100 within 90 seconds after the start of the test, and may not exceed 200 within 4 minutes after start of the test. The only material excepted is neoprene foam cushioning. (Department of Transportation Guidelines for Flammability and Smoke Emission Specifications - TSC-74-LFS-2).

Further Questions Should Be Directed To:

James P. Wilhelm, SRI Technology Applications Team, 333 Ravenswood Ave.
Menlo Park, California 94025. Telephone: (415) 326-6200, extension 3520.

This Problem Statement calls to your attention significant technological needs in an important area of concern in the public sector. We hope to bring to bear on this problem the information and expertise that resides in NASA. If you feel you can contribute, please relate your ideas to the Technology Utilization Officer at your installation, or to the team representative named in the statement.

Table C-2 (Continued)

CURRENTLY USED MATERIALS (BY PART) AND FIRE RESISTANT CHARACTERISTIC	
<u>PART/MATERIAL</u>	<u>FIRE-RESISTANT CHARACTERISTIC</u>
Thermal and acoustic insulation	
A. walls - fiberglass	
walls - closed cell neoprene foam	meets NFPA standards
roof, floor - urethane foam	meets NFPA standards
between roof and side - closed-cell flexible polyurethane foam	burn rate $\approx$ 1.5 in./min. in horizontal bar test
B. fiberglass	permanently fire resistant
C. fiberglass (Gustin Bacon, type #75 Ultralite	flame spread index $I_s < 50$ (ASTM E-162)
Wall and ceiling panels	
A. polyester reinforced fiberglass	
B. melamine (Textolite TX 4300)	
melamine (Consoweld Dusky Walnut VT-W-48)	
window masks - fiberglass	permanently fire resistant
C. fiberglass	
melamine	
Floor covering	
A. heavy weight wool velvet weave with level loop pile	flame spread class 75 (ASTM E-84)
lead impregnated vinyl and poly- urethane foam carpet pad	
B. RCA Rubber Co. Transit Flor (vinyl asbestos)	
C. wool carpet	flame spread < 75 (ASTM E84-61)
polyester back	
Seat cushion	
A. resilient molded foam	
B. neoprene foam padding	flame spread 25 or less (ASTM E166-67)
C. resilient foam of latex urethane (SPI Type II base)	exceeds values stipulated by Boston Fire Code and DOT FHWA Standard #302
Seat covers	
A. vinyl and fabric	meets NFPA standards
B. vinyl coated knit nylon (Uniroyal Naugahyde Decor Poly- meric Vinyl, Supreme Grade DC-16)	meets Federal Specification CCC-A-680, latest issue, Treatment A-1

Table C-2 (Concluded)

Seat covers (continued)

- | | |
|--|--|
| C. plastic coated fabric and woven upholstery fabric | exceeds value of Boston Fire Code and DOT FHWA Standard #302 |
|--|--|

Seat frame

- B. fiberglass (glass reinforced polyester)

Weathering strips and door seals

- A. elastomeric material

Door guide

- A. polyvinyl chloride

Hand grip

- A. polyvinyl chloride

Side windows

- A. laminated safety glass
- B. laminated safety glass
- C. laminated safety glass

such as the Veterans Administration and the Rehabilitation Service Administration's Engineering Centers will aid in the implementation, operation, and deployment of the California Rehab-Engineering Service Delivery Model.

Under a grant from the National Science Foundation (NSF), Innovative Systems Research Inc. (ISR) is assessing the potential of computerized conferencing techniques in meeting the communication needs of the rehabilitation engineering communities.* Computerized conferencing uses computers to structure and facilitate communication. The technique relies on the information storage and processing capabilities of the computer conferencing system to eliminate time and geographic barriers. During the project, IRS will assess how well a particular conferencing system meets the rehabilitation community's needs for greater accessibility of information, timely feedback, and more efficient means of communication among those engaged in device research and development.

The system being evaluated is Electronic Information Exchange System (EIES) developed by the New Jersey Institute of Technology (NJIT). The study participants are a cross section of persons and agencies in the rehabilitation device professions, including those in basic and applied research, marketing, production, distribution, and consumption. EIES is maintained on a minicomputer at NJIT. For 12 months, participants send and receive information via personal computer terminals with acoustic couplers that accommodate their telephones.

The EIES has a number of capabilities. These include:

- Messaging--messages can be sent directly to anyone with access to the system. Recipients are alerted to waiting messages when they sign on to the system, and senders receive confirmation when their messages have been received.
- Conferencing--this can be used for topic-oriented discussions over any period of time. The system maintains a permanent transcription of comments that is available to conferees at any time.
- Notebooks--personal storage space for text composition and editing is provided. Notebooks can be shared with other members for joint authorship of papers or comments.
- Bulletins--public communication space for use as an on-line newspaper or electronic journal.

*The project entitled, "Electronic Information Exchange in Research on Devices for the Disabled" is supported by the Access Improvement Program, Division of Science Information, NSF.

The project has few controls other than general monitoring by IRS project leader Jane McCarroll. It is hoped that the best network organization for the individuals will evolve as the experiment continues. The participants are encouraged to use EIES capabilities to support their work, share product evaluations, exchange ideas, discuss information and research results, communicate conference plans and schedules, communicate with remotely located developers and users of specific devices, and explore different methods and techniques for making use of the system. For example, one system member organization is working on a software linkage between EIES and an automated data base of devices that would essentially establish the data base as a system member and enable everyone else in the system to query it on-line for device data.

Ultimately, ISR intends to use the techniques and methodology used in the current effort in the development of further applications of computerized conferencing. The primary objective will be to assist other organizations and agencies in rehabilitation technology and services for the disabled to adapt the medium to their needs.

NASA Technology Applications Teams

A primary difference in the operation of a technology applications team (TAT), as contrasted to the other program elements briefly described in this section, is that the team actively seeks out new problems (through personal visits, telephone calls, attendance at conferences) that display potential for solution by the application or adaptation of aerospace-derived (NASA) technology.

The overall technical approach and methodology of a TAT is to field an interdisciplinary corps of experts to identify and validate public sector problems; to then identify and locate the source of the NASA technology most closely addressing that problem; and by means of adaptive engineering efforts, if necessary, at NASA centers or in the private sector, to modify that technology to obtain the closest fit possible with the problem. The team also involves private sector vendors or manufacturers as early as possible in the transfer operation to ensure the commercialization and availability of the technology in question.

The primary functions of a TAT are to plan, implement, coordinate, control, and evaluate a program for optimizing the match between user (public sector) problems and potential solutions in the NASA-derived aerospace knowledge bank. The team operates primarily as a broker or linker between the suppliers/offers of technology and the users of products, processes, and services, based on new technologies.

A key function of the TAT is the selection and validation of problems. Operationally, the first step of this process occurs during initial contacts or visits with the user. After the NASA TU Program, its objectives, and the role played by all its parts has been described, the team member solicits information about the user's technological problems,

focussing on those potentially soluble by an advanced (i.e., NASA-derived) technology. The types of problems usually obtained as a result of this type of solicitation fall into three general categories:

- Technically valid problems--i.e., problems for which a technical solution appears feasible, but whose cost has not been estimated.
- Technically and economically valid problems--i.e., problems for which a technical solution appears feasible and cost constraints are such that a product, process, or service implementing this solution would be used even if it cost more than the product, process, or service it is to replace.
- Technically valid and economically invalid problems--i.e., those that are labeled "wish list" problems. These are usually preceded by: "Wouldn't it be nice if we had a ..." These problems are usually poor in technical content and their implementation is obviously constrained by cost.

Should a solution be found, it is fostered to the prototype stages of development in the hope that a private commercial manufacturer will be interested enough to market it and thus make it available to the consumer. Unfortunately, the commercialization of NASA technology and other government-funded programs has not progressed to the point of being felt by large numbers of disabled consumers. The process of technology transfer seems to be restricted at the prototype stage; ideas are generated about problems related to rehabilitation, but not all equipment problems are being considered, and few ideas are translated into marketed products for general consumption.

Proposed Rehabilitation Technology Applications Unit*

Many of the present research results and technical developments that can benefit the lives of the handicapped are currently not made available to them. The development effort ceases when the technical research is completed, and its potential application is either neglected or fails to materialize because the research did not start with a sound handicap-oriented goal or there are no means of distribution. Research to develop solutions should be more appropriately balanced with research on alternative ways to make these solutions available to consumers.

Requests for information and literature searches may result in research utilization, but only if they are accompanied by sufficient consultation and follow-up. The necessary follow-through can be

*Clarence Nicodemus, a rehabilitation engineer, proposed a rehabilitation technology applications unit in 1976 under the name of Secondary Technology Applications and Rehabilitation Team (START). His concept paper was helpful in writing this section.

accomplished by an efficiently run Technology Applications Unit. An effective Applications Unit can substantially reduce the time span between knowledge acquired and knowledge applied. The ultimate objective of this office is to assist in the research, development, demonstration, and distribution of the accomplishments of science and technology for handicapped people.

The technology utilization process could assist in mission-oriented research programs by making available necessary technical support for communication and information processing. The research efforts for such a program should be based on problems and needs of the handicapped which, if solved, would decrease dependence on public financial assistance. Breaking this cycle of dependence through properly designed and manufactured equipment could increase personal independence, vocational and economic productivity, and educational self-development for the handicapped.

The primary functions of the unit would be to plan, implement, coordinate, control, and evaluate a program for optimizing the match between public sector user problems and potential solutions in the NASA-derived aerospace knowledge bank. A technology applications team would operate primarily as a broker or linker between the suppliers/offers of technology and users of products, processes, and services based on new technologies.

Some primary objectives of the proposed applications unit program should be:

- A better needs determination of the disabled consumer and the rehabilitation network.
- Identification of state-of-the-art knowledge in specified areas (both foreign and domestic).
- Applied research for prevention of disabilities with an emphasis on public safety.
- Identification and ranking of problem areas by priority that require further research development.
- Aid in the development of systems and devices for the handicapped.
- The matching of problem areas with available scientific solution(s).
- Identification of barriers to effective service delivery and transfer of technology to the handicapped.
- Distribution and marketing studies that ensure more rapid application and acceptance of new techniques by practitioners and consumers.
- Arrangement for clinical trials, technology testing, prototype production, where applicable.

- Linkage of research outcomes to production entities and allocation of the necessary incentives to ensure the production of such entities.

The purpose of the application team discussed above would be to complete the transition from basic and applied research to production and marketing. The applications unit would act as a liaison to improve contact with all three surfaces of the rehabilitation services interface--technology, consumer, and provider. The office could offer a unique solution and secondary technology application and rehabilitation. Generally, the overall objective would be to facilitate the transfer rate in volume of advanced technology in materials systems analysis, engineering design processes, and medical developments as they relate to rehabilitation equipment services for the consumer and consumer provided.

An existing model for technology utilization in rehabilitation is supplied by the Innovative Matching of Problems to Available Rehabilitation Technology (IMPART) program in Texas. IMPART functions in a similar manner to the NASA application teams.

IMPART was established by the Texas Rehabilitation Commission in collaboration with Southwest Research Institute. The project was funded by a grant from the Research Utilization Office of the Rehabilitation Services Administration. The purpose of the program is to make the prescriber and the user segments of the rehabilitation community aware of available equipment, devices, and technological information related to rehabilitation and everyday living. IMPART is a public service and is available to anyone who has a work-related problem. It is open to handicapped persons and employers, counselors, and doctors working with handicapped. The primary emphasis is on the rehabilitation counselors in the field and the problems that they encounter.

To input a problem, an individual submits a problem statement form (see Figure C-5) describing the situation. Usually the problem originator is contacted by a rehabilitation engineer who discusses the problem before and during the search for alternative solutions. (See Figure C-6 for a sample problem area checklist.) Problem solutions come from personal knowledge of the rehabilitation engineering area, catalog searches, data bank searches, and direct contact with rehabilitation engineering and devices design personnel.

Problems received are categorized into three classes:

Class I: those for which a suitable technology exists (most fall into this category).

Class II: those on which research is in progress and for which a suitable technology is being developed and tested.

Class III: those currently beyond the state of the art. They may suggest areas for future research and technical development.

Problem Statement

Fill out this form and mail to the address shown below.



INNOVATIVE MATCHING OF PROBLEMS TO AVAILABLE REHABILITATION TECHNOLOGY

Title: _____ Date _____
Originator: Name _____ Position _____
Firm or Agency _____
Address _____
City, State _____ Tel. _____

What Is Needed: _____
Check 3 descriptive words on the back of this page
which best describe this need.

Disability: _____

Specific Physical Limitations: _____

Is Condition Progressive? _____

Other Information/Constraints, Specifications, Etc.: _____

For Project Personnel Use Only

Date: Received _____ Closed _____

IMPART Personnel: TRC _____ SWRI _____
UTA _____ Other _____

Descriptors: _____
Disability _____ Area _____

Strict confidentiality will be observed at all times.

Frederick O. Bohls, Ph.D.	Charles J. Lenger, Sr.
Project Coordinator	Rehabilitation Engineer
Texas Rehabilitation Commission	Southwest Research Institute
118 East Riverside Drive	6220 Culebra Road
Austin, Texas 78704	San Antonio, Texas 78284
512 - 447-0100	512 - 684-5111

FIGURE C-5 SAMPLE IMPART PROBLEM STATEMENT FORM

DAILY LIVING

- ___ Eating/Drinking/Feeding
- ___ Bathing
- ___ Toilet
- ___ Dressing/Clothing
- ___ Grooming
- ___ Sleeping
- ___ Safety/Security

HOME MANAGEMENT AND ADAPTATION

- ___ Food Preparation and Serving
- ___ Child Care
- ___ Cleaning/Laundry
- ___ Other Home Maintenance

FURNITURE (Home/Office)

- ___ Chair
- ___ Table/Desk
- ___ Bed
- ___ Couch

MOBILITY AIDS

- ___ Wheelchair
- ___ Wheelchair Accessories
- ___ Walkers
- ___ Canes, Crutches
- ___ Orthotics
- ___ Prosthetics
- ___ Lifts, Transfers, Elevators
- ___ Other Stabilization or Positioning Aids
- ___ Electronic, Ultrasonic, Laser, etc.
- ___ Personal Vehicle, Specialized, Unlicensed

TRANSPORTATION

- ___ Automobile/Automotive Hand Controls
- ___ Adapted Van
- ___ Transfers/Lifts
- ___ Personal Vehicle, Specialized, Licensed
- ___ Wheelchair Restraints
- ___ Automotive Power Assists
- ___ Emergency, Safety Equipment/Automotive
- ___ Buses, Minibuses, Ambucabs

COMMUNICATION

- ___ Amplification Devices
- ___ Speech Producing Devices
- ___ Telephoning
- ___ Braille/Braille Writing
- ___ Writing
- ___ Typewriting
- ___ Reading
- ___ Communication Boards/Electronic
- ___ Special Signaling Devices
- ___ Sensory Conversion Devices
- ___ Command/Control

MEDICAL THERAPY

- ___ Surgical
- ___ Diagnostic and Testing
- ___ Exercise
- ___ Therapy Devices
- ___ Muscle/Nerve Stimulation

RECREATION

- ___ Crafts
- ___ Sports
- ___ Games
- ___ Devices

FIGURE C-6 IMPART PROBLEM AREA CHECKLIST

IMPART's methodology is to identify:

- Appropriate methods, materials, and devices already developed or in development.
- A commercial source or established method.
- Modification of a commercially available device or fabrication of special apparatus will be recommended.

To date, IMPART has acquired more than 100 problem submissions. Most of these have been submitted by rehabilitation counselors. Titles for some of these problems are as follows:

- Alert for Deaf Restaurant Worker
- Communication System for Athetoid Cerebral Palsied Client
- Telephone Capability for Deaf
- Deaf Alert--Telephone, Baby Cry, Smoke, Emergency Vehicle
- Margin Alarm for Deaf (Typewriter)
- Extend Usefulness of Hearing Aid
- Large Field, Low Power Lens
- Lamp Identifier for Blind
- Sewing Fixture for Blind
- Bottom Margin Alarm for Blind (Typewriter)
- Recording Cuing for Blind Disc Jockey
- Heliarc Machine Control for Quadriplegic
- Writing Aids for Paralyzed Clients
- Carrier for Electric Wheelchair
- Stability Assist for Bus Egress
- Proportional Control "Trainer" for Electric Wheelchair
- One Hand Typewriter
- Elevating Wheelchair for Cerebral Palsied Office Worker
- Female External Urinary Collection Device
- Mobility Aid for Osteogenesis Imperfecta
- Housework Aid for Paraplegic
- Tire Cutter for Sheltered Workshop
- Protected Environment for Woodworker
- Portable Suction/Support Bars

In conclusion, therefore, the establishment of a Rehabilitation Technology Applications Unit could serve as a clearinghouse for problems and ideas. This would entail creating a central idea bank. The purpose would be to clear the ideas against existing lists of equipment and have a functional cross-referencing basis that would facilitate access to information from a variety of perspectives.

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