

**INDUSTRIAL BENEFITS AND FUTURE EXPECTATIONS  
IN MATERIALS AND PROCESSES RESULTING  
FROM SPACE TECHNOLOGY**

by

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As has often been stated, one of this nation's most vital resources is technology. However, just like any other resource, technology must be applied if it is to be useful. Properly utilized, technology can improve our jobs, our health, our homes, and our future. And, like other types of resources, how effectively we use technology will not only impact the quality of our lives, but also that of future generations.

Without a doubt, the foremost pioneer and motivating force in the field of technology utilization has been NASA. In 1958, the law creating NASA contained a specific provision mandating "the widest practicable and appropriate dissemination of information concerning its activities and results thereof." In those days, NASA was breaking new ground not only in space research, but also in applying the results of that research to nonaerospace applications. Since then, NASA has stimulated progress in many areas only remotely related to the purpose of its original research.

One of the areas in which industry has benefited enormously from the results of space research is in new materials and processes. It would be impossible to cover the entire spectrum of developments in these fields which could be traced back to NASA. Therefore, the remainder of this discussion will focus on highlights of several of the technologies which have been successfully transferred, areas of recent and current research which offer future potential, and a new program NASA has initiated to speed up transfers of this type — the Manufacturing Applications Team.

One area that quickly comes to mind when considering materials which have resulted from aerospace research is anticorrosion coatings. Needless to say, corrosion is a major problem in such field as bridge construction, off-shore oil rigs, and pipelines in the marine industry. Traditionally, coatings used for these applications have relatively short lifetimes (4 to 6 years), frequently require two coats, and are expensive. A zinc-rich silicate paint, originally developed by NASA's Goddard Space Flight Center, has been adapted and commercialized for these applications. Because of a special binder, this paint exhibits longer life and superior adhesive characteristics over those previously used. In many instances only a single coat of paint is needed rather than the traditional two coats. Additionally, the silicate paint also covers more area per gallon and costs less to purchase. Thus, this new coating offers advantages in lower materials costs, reduced labor hours to apply, and fewer applications over a given time span. One study has estimated that there is a \$2 billion annual market in applying coatings of these types, therefore, the economic payback can be very real indeed.

Fire retardant coatings is another example where NASA technology has resulted in improved materials. These coatings were originally developed as part of the heat shielding and fire retardant systems for manned spacecraft. They are now commercially available and are receiving wide acceptance in construction of office buildings, manufacturing plants, schools, and a variety of other buildings. The coating contains a subliming compound which vaporizes without melting at a certain temperature, absorbing heat in the process. The coating is sprayed or brushed onto building components such as steel beams, electrical cables, etc. When the coating compounds sublime, they absorb heat from the flame as well as from a porous char layer which serves as a highly efficient insulation. In this manner they retard flame spread and delay ignition of combustible materials.

Similarly, polyurethane foams developed for insulating the Saturn rocket have been used as insulation by boat manufacturers. Such insulation is needed for insulating such areas as fish storage compartments. The polyurethane foam is used in place of cork and fiberglass and provides better, cheaper, and more reliable insulation. To date, more than 40 tuna boats have been insulated in this fashion.

Safer tires is another area where NASA developed materials have made an impact. A flexible rubber originally developed for the mobile equipment transporter used during the Apollo 14 mission, coupled with fibers developed for shroud lines for the Viking lander, have been used by Goodyear to develop a new winter radial snow tire for automobiles. Conventional tires lose their pliability below freezing. However, this new rubber remains pliable even at  $-95^{\circ}\text{F}$ . The fiber used in the cords of the tire have a chain-like molecular structure that gives it incredible strength in proportion to its weight. On a pound-per-pound basis it is five times stronger than steel. Goodyear started production of these tires in 1974.

Energy absorbing foams first used by NASA's Ames Research Center in the design of aircraft passenger seats have also found their way into applications in other areas. This particular material is an elastomeric, open-celled foam which exhibits three times the shock absorbing capacity of previously used materials. Applications have included foams for body protection, linings for football helmets, baseball chest protectors, and padding in soccer shin-guards. In addition to athletic applications, the foam is also being used in wheelchairs, x-ray table pads, and off-road vehicle seats. This material exhibits such shock absorbing characteristics that it is claimed a 3 in. thick pad can absorb all the energy from a 10 ft fall by an adult.

Needless to say, a discussion of materials which have resulted from space research could go on almost indefinitely, and would certainly include areas such as advanced composites, new alloys, lubricants, special polymers, and many others.

As far as processing is concerned, the fruits of NASA technology have been equally as widespread. For example, NASA fracture-toughness tests originally devised to check spacecraft structures helped one farm implement manufacturer select materials which would enable the design of larger, more durable plows. These larger plows, coupled with more powerful tractors, have helped to increase productivity by 10 percent in this area. These same fracture-toughness testing techniques have also been used by electric utilities and nuclear pressure vessel manufacturers for detecting flaws which might lead to brittle fractures.

The use of computer aided techniques for test, inspection, and diagnosis is another area where industry has benefited significantly because of NASA's pioneering efforts. For example, technology contained in an environmental control and life support system developed for a prototype space system included a subsystem to monitor the performance of various items of equipment, detect failures, and identify specific malfunctioning units. This subsystem provided a springboard to a commercial, computer-operated diagnostic system for isolating malfunctions in trucks and autos. In just 25 min, it can run through a total auto health check comparing operation of each part with factory specifications. This system is employed by used car, and even new car dealers to satisfy customers that the vehicle they are buying is in tip-top shape. In use at repair stations, the system not only identifies trouble it also tells the mechanics — and the customer — why a faulty component is bad and how it may be fixed. After repairs have been made, a second printout shows the customer that the problem has been corrected.

Although not processing per se, structural analysis is another area where NASA has substantially advanced the state-of-the-art. Computer aided design techniques which enable engineers to create mathematical models of space vehicles and simulate their performance were developed by NASA some time ago. This technique enables engineers to study performance and structural behavior of a number of different designs before settling on the final configuration and proceeding with construction. From this base of aerospace experience, NASA's Goddard Space Flight Center developed the NASTRAN general purpose computer program, which offers an exceptionally wide range of analytical capability with regard to structural design. NASTRAN has been applied to autos, trucks, railroad cars, ships, nuclear power reactors, steam turbines, bridges, and office buildings. NASTRAN is essentially a predictive tool. It takes a look

at a computerized representation of a design and determines how the structure will react under many different conditions. It can, for example, note where high stress levels will occur and identify potential failure points that need strengthening. Conversely it can identify over-designed areas where weight and material might be safely saved. NASTRAN can also evaluate how pipe stands up under strong fluid flow, how metals are affected by high temperatures, how buildings will fare in an earthquake, or how powerful winds will cause a bridge to oscillate. NASTRAN is quick and inexpensive. It minimizes trial and error in the design process and makes possible better, safer, lighter structures while affording large scale savings in development time and materials. Because NASTRAN is widely employed in industry, it represents an enormous national economic benefit. One study estimated that in the period from 1971 to 1984, NASTRAN will return more than \$ 700,000,000 to U.S. economy.

These are only a few of the highlights of some cases where NASA technology has improved industrial processing. There are numerous other examples in areas such as test and inspection, welding procedures, contamination control, tooling, cryogenics, instrumentation, safety, and material handling.

The future potential for successful transfer of NASA technology to non-aerospace industries looks extremely bright. For example, a novel composite material developed through Ames Research Center's continuing studies on high temperature space materials may be useful for better brake linings. One of several compositions which have been fabricated demonstrates increased wear resistance and lower costs over conventional brake lining materials. It also exhibits a constant coefficient of friction at temperatures as high as 650° F, a region where conventional brake linings fade markedly. These new materials should substantially reduce maintenance and replacement costs in public vehicles and also assist the trucking industry in increasing braking capability in response to a directive issued by the National Highway Traffic Safety Administration.

Recent work by Langely Research Center can potentially improve our ability to separate nonferrous metals from industrial scrap and, thereby, reduce raw material costs through recycling. The technique used for separating the scrap is based on the concept of ferrofluids, which are suspensions of magnetic particles whose apparent density can be varied by regulating the gap between an electromagnetic field. This concept was originally developed by NASA to control liquid propellants under zero gravity conditions. The ferrofluid is magnetically sensitive and ferrous materials in a molten state will sink because of their higher density, whereas nonferrous materials will float. This technique is currently in a pilot plant development stage and has been used to separate

aluminum, zinc, and copper from various types of scrap. The Air Force is also working on separating titanium chips using the process. The ferrofluid concept is also being used for rotary shaft seals to provide zero leakage, low maintenance, and easy installation on rotary shafts protruding into vacuum processing systems.

There are many other NASA technologies which have potential applications in nonaerospace industries which will be discussed later in this document.

The presentation's final topic of discussion is NASA's new Manufacturing Applications Team (MATeam). As the name implies, the MATeam is composed of technical experts who will work with professional societies, industrial associations, various government agencies, and individual companies to define significant and widespread manufacturing problems and identify the appropriate space technology for potential solutions. In addition to identifying appropriate technologies, the team, in cooperation with NASA and industrial organizations, will attempt to demonstrate solutions by conducting applications engineering work in developing prototypes when appropriate. That is, the team will actively pursue the transfer and implementation of technologies similar to those described earlier in the presentation.

One might wonder why NASA has started the MATeam program in light of its past successes in technology transfer. To understand the reasons behind the MATeam, one must first have an appreciation of the fundamentals of NASA's technology utilization program. In short, the purpose of the technology utilization program is to bridge the gap between NASA technology and industry application. To accomplish this, NASA relies on four major types of activities: publications, information centers, applications projects, and application teams. Each activity has a well-defined role to play in technology transfer. The publication program is aimed at disseminating information concerning NASA technology. The information centers, of which there are 12 scattered around the country, are a source where individuals and companies can go to have the vast storehouse of NASA information searched in view of their needs. Applications projects are special efforts aimed at solving a particular problem using specific NASA technologies. Applications teams, however, are set up to actively pursue the application of NASA technology to a specific sector of the economy. They are intended to fill the gap between the person or organization with the need and the person or organization with the solution.

Past experience has shown that one of the most effective ways to accomplish technology transfer has been through applications teams. Until recently, NASA has concentrated its applications teams' activities in the areas of biomedicine, transportation, and the needs of state and local governments. The MATeam is the first applications team directed to solving manufacturing problems through the application of aerospace technology.

During the first year of the program the team will concentrate its efforts on working with manufacturing industries in such areas as machine tools, heavy equipment, and electronics assembly. If the concept is successful the team will expand its scope of operation to include other industries in the future.

In closing, it should be noted that probably the most important impact that technology transfer can have is on our overall national productivity. During the past ten years, productivity gains in the U.S. have been lagging considerably behind those of Western Europe and Japan, and one of the ways to reverse this trend is through the application of more advanced technologies. Thus, it becomes vitally important to the long range well-being of our country to maximize the transfer and application of these technologies.